A REPORT ON

NEW ENGLAND HYDROELECTRIC DEVELOPMENT POTENTIAL

BY

NEW ENGLAND FEDERAL REGIONAL COUNCIL
ENERGY RESOURCE DEVELOPMENT TASK FORCE
HYDROELECTRIC FACILITIES WORKGROUP

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JUNE 1976

REPORT ON

POTENTIAL HYDROPOWER FACILITIES IN NEW ENGLAND

(Prepared for Federal Energy Administration)

JULY 1976

INDEX

INDEX OF SELECTED 18 SITES

PREFACE

This report is a product of the New England Federal Regional Council's Energy Resource Development Task Force.

The Federal Regional Council is an interagency, inter-governmental coordination group. Its purpose is to make a very complicated, three tiered governmental system efficient and responsive to the real needs of all citizens. FRC membership includes the heads of the ten principle grant making federal agencies, several ad hoc members in such fields as energy and economic development and land use planning and a host of partners among state and local officials and the agencies which they represent.

The Federal Regional Council's Energy Resource Development Task Force is composed of representatives of federal agencies, the New England Governors, the New England Regional Commission and the New England River Basins Commission. The Task Force Steering Committee members are Robert W. Mitchell, Chairman, FEA Regional Administrator, John A. S. McGlennon, EPA Regional Administrator and Roger Sumner Babb, Department of Interior's Regional Secretarial Representative. Principle objectives are to:

1. Reduce the Region's high dependence on petroleum and its attendant high costs.

2. Reduce the Region's adverse weighted average energy cost differential versus the balance of the United States, and thereby

3. <u>Improve</u> both New England s energy posture and <u>industrial investment climate</u> by providing an inter-agency process that will most efficiently meet anticipated needs and <u>compress the lead time</u> required for energy development.

The paper will address: (1) philosophy of electric generation; (2) a survey of existing mix of investor generation, present and to 1987; (3) existing and undeveloped conventional hydro sites exceeding 5 MW installation; (4) costs and benefit ratios; (5) pump storage; (6) impeding factors of hydropower (environmental); (7) restoration of small dams for power generation; and (8) government statutes for implementation.

FY '76 work of the Task Force has been carried out under the leadership of six Federal agencies in 14 specific work areas:

<u>Lead Agency</u>	<u>Work Areas</u>
Federal Energy Administration	. Energy Statistics and Projections
	. SNG/ LNG? LPG Facilities
	. Emergency Storage

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Lead Agency	Work Areas
Environmental Protection Agency	. Refineries . Electric Power Plants . Emergency Storage
Corps of Engineers	. Hydro-Electric
Department of Transportation (USCG)	. Energy Related Marine Terminal Facilities
Department of Interior	. OCS . Coal . Coastal Zone Management
Energy Research & Development Administration	. Nuclear R, D & D . Solar R, D & D . Resource Conservation R, D & D

Each Task Force work group includes concerned representatives from both public and private sectors. For more information concerning Task Force work, contact the Task Force Chairman.

SUMMARY

Faced as we are with a threatening energy crisis and in a period when we are looking hard at the full utilization of fossil and nuclear fuels new looks are being directed at a recently neglected source of electric generation - hydropower. Water is essentially an inexhaustible resource although it must be managed to be effectively productive. When compatible with the environment, hydroelectric plants excel other forms of power generation because of their low operating costs, low machine outage rates, immediate power availability, recreation value of reservoirs or conservation pools, and other non-power usages of the water.

New England faces this predicament of fossil fuel dependency more than other sectors of the country. For climatic and geographic reasons, it is water endowed but may not be developing its full potential of hydropower, 7% vs. 16% nation-wide. This report addresses undeveloped hydropower in New England and develops the following:

1) There are 9 major sites having a benefit to cost ratio in excess of unity. The potential plants range in capacity from 25,000 KW to 760,000 KW (1,220,000 KW total) and would have a total average annual output of 2 billion kilowatt hours. If all were developed the total construction cost would be $820,000,000.

2) There are 9 major sites having a benefit to cost ratio of 0.8 to 1.0 meritorious of further study. The plants would range from 20,000 KW to 220,000 (585,000 KW total) and would have a total average annual output of 1.17 billion kilowatt hours. If all were built the total construction cost would be $613,815,000.

3) Summarizing 1) and 2):

No. of Sites	18
Installed capacity	1,805,000 KW
Average Annual Output	3.2 billion KWH
Total Construction Cost	$1.43 billion

4) Sixteen of the plants are in Maine and New Hampshire and 1 each in Massachusetts and Connecticut.

5) Tidal power has a potential and is being updated to develop a current financial assessment. It could provide 500,000 KW (expansible to 1,000,000 KW) and 1.9 billion KWH of energy.

6) There is an estimated number of some 800 small dams in New England that have previously been utilized for power generation but are now in varying degrees of disrepair or if not previously used for power generation may have power potential. There has been an increasing awareness of these and interest in restoring or developing them. The thought has merit and should be explored. The

generating capacity of each would be small, averaging in the range of 200 to 500 KW. Assuming that 30% might be developed, the total capacity could amount to 85,000 KW. Cost and average annual output are not ascertainable pending further study. This power could possibly be used to street lighting, municipal buildings, and light industries.

7) There is a total of 19,300 - 34,080 MW of undeveloped pump storage. Although not a direct fossil or nuclear fuel saver it has economical advantages.

8) The development of hydroelectric facilities have impact on environmental features. This is addressed herein.

9) As noted at several points herein, very close liaison will be needed with the investor-owned utilities. Transmission, marketing and integration with their system will require in depth studies and coordination.

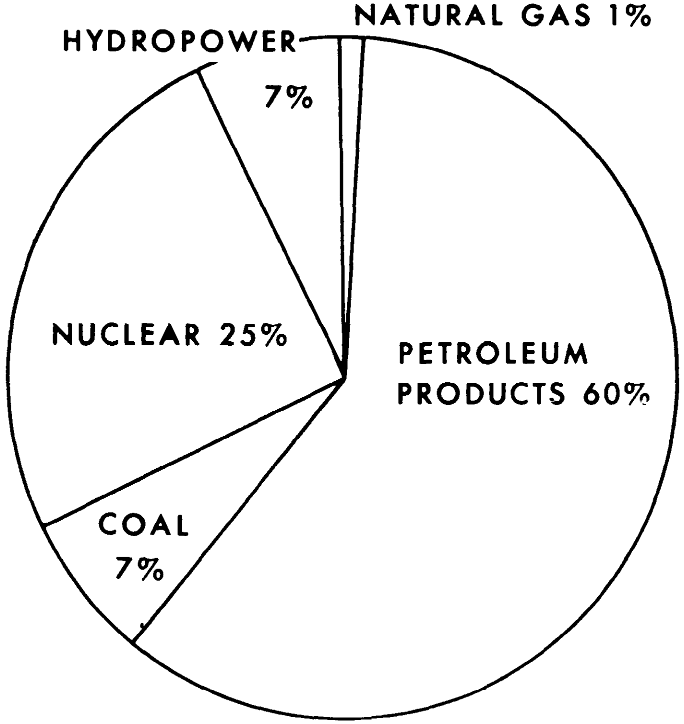
10) With the exception of possibly some small dams no immediate relief is forthcoming. However, if oil and nuclear problems continue or escalate now is the time to move to face the early development of hydropower.

11) As stated in the Preface, this report has been prepared by an ad hoc committee with limitted funds and staff. The committee does feel that an in-depth study of hydroelectric

power is meritorious and is recommended. One such recommended plan of study and implementation prepared by the New England River Basin Commission is included in the report for consideration by decision-makers.

ELECTRIC GENERATION FUEL SOURCES
1974

NEW ENGLAND



UNITED STATES

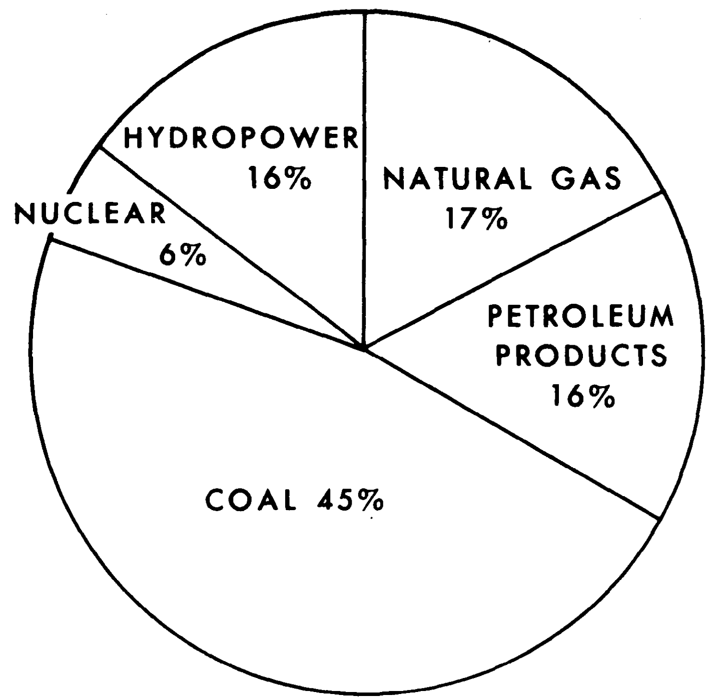


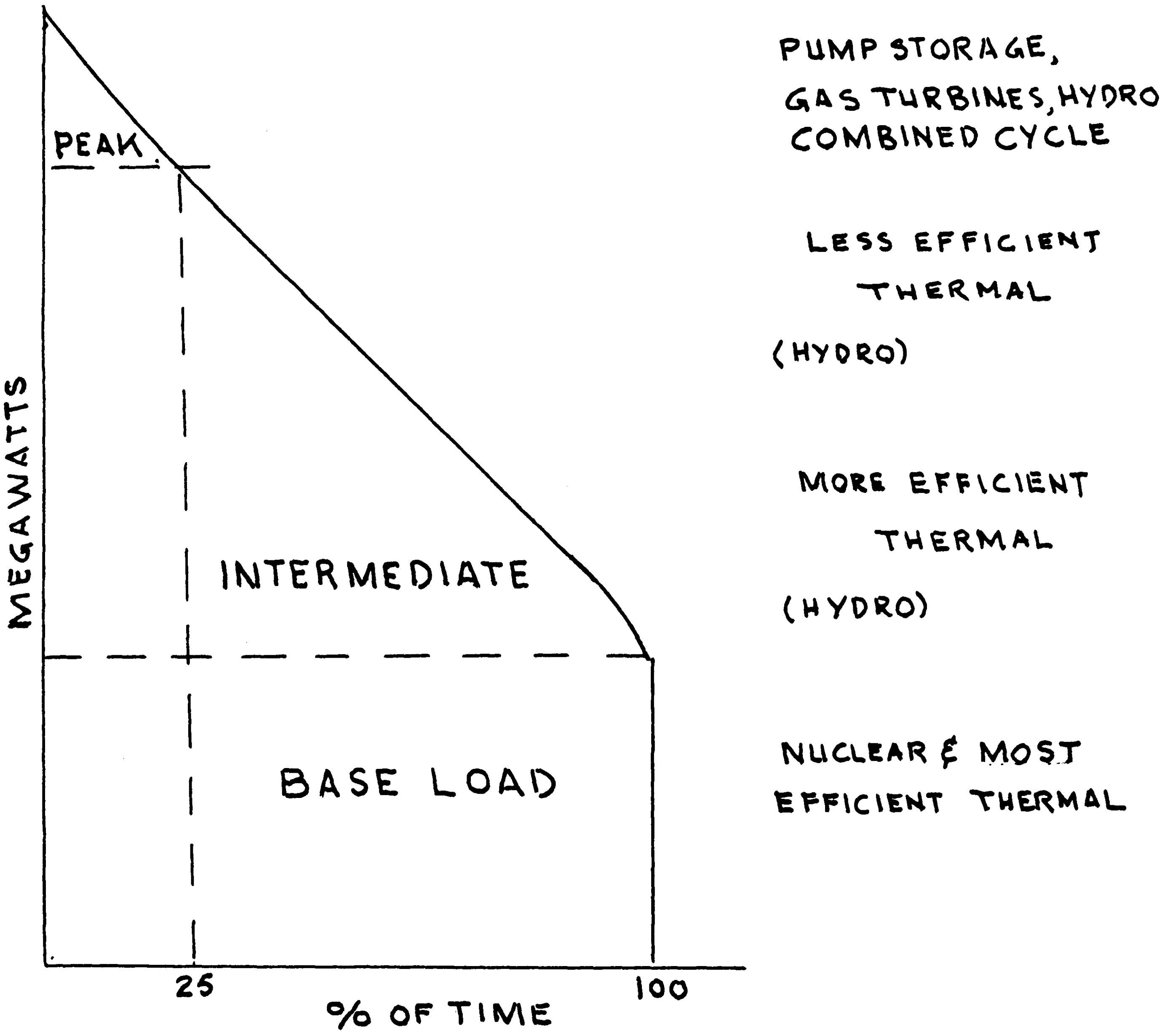
PLATE I

CHAPTER I

PHILOSOPHY OF ELECTRIC GENERATION

In order to understand hydroelectric power engineering, there are many terms and facets related primarily to power and the power industry and a clear understanding of these terms is necessary. The required load can be divided into three types: peak, intermediate, and base. Peak load is the maximum load and is normally of short duration. This load varies from a short period of two to three hours in the winter to probably seven hours in the summer. Base load is the minimum load occurring continuously throughtout the day. In between is what may be called the intermediate load which varies and reflects the demand at any one particular time.

On a mixed energy system, load is usually assigned as follows: base load is assigned to nuclear and the newer or more efficient thermal plants; intermediate load is broadly assigned to thermal plants (although nuclear or hydro may be used to assist); and peak load is handled by hydro, pumped storage, gas turbines, and combined cycle whichever is most economical. As you may note from Plate II base loads operate 100% of the time, whereas the peak load operates in the 10-25% range. The ratio of the average load in a system during a specified period to the peak load during that period



TYPICAL LOAD DURATION CURVE
AND PLANT DISPOSITION

Plate II

is called the load factor. This runs about 55%. Plant factor is a term to denote the use of the individual power-producing facility. It is defined as the ratio of the average demand on a plant during a specified period to the total rated capacity of the plant expressed as a percent. For example, for economic reasons, a nuclear plant would have a high plant factor of 70-80%. In contrast, the plant factor for a hydro plant when used solely for peaking usually runs from 10 to 25%.

Hydropower, excluding pumped storage which is treated elsewhere, it significantly different from the other methods of generation. Its fuel, as the name indicates, is water. This fuel is not limitless in the true sense, but is dependent on many factors; site conditions, stream flow, climatic conditions, critical hydro period, tailwater conditions, storage conditions, head, and power drawdown. There are basically two types of hydro plants: a storage plant such as the Moore Station (140.4 MW capacity) on the Connecticut River, and the proposed Dickey-Lincoln School project (830 MW) on the St. John River in Maine; and a run of river plant such as Vernon (24.4 MW) on the Connecticut River.

A storage plant is designed to provide a large quantity of storage which sometimes combined with additional upstream storage can supply the water necessary to generate needed peaking capacity during hot summer days when riverflows are usually low, as well as during the winter season when the demand for energy is the greatest. Over 50 percent of the annual streamflow occurs during the spring runoff, and it is during this period that the reservoir stores water. The reservoir is then drawn down during the summer, fall, and winter seasons which augmented by natural streamflow allows the generation of the design peaking capacity. This method of storage maximizes the streamflows and substantial blocks of power can be generated at high plant factors for extended periods of time. For example, if Dickey-Lincoln School were run at 100% plant factor, the power pool would be drawndown in 37 days and the plant would become inoperative.

A run of river plant such as Vernon has a limitted amount of useable storage or pondage and can only store daily flows that are released as large slugs for short intervals when peaking capacity is required in the power grid. Vernon Dam is operated to supply base load during the spring runoff to take advantage of the abundant streamflows; peaking power during the low flow summer months; and a combination of both modes of operation during intermediate river flows in late fall and winter. The installed capacity is smaller than the storage type largely due to the wide seasonal variations in streamflow as well as limited storage.

In the New England area it seems that the use of hydro is best suited to peak power. It is highly adaptable to meet sudden or sharp needs or peak demand. The greatest advantage of peaking hydro plants has come to be known as the hydroelectric advantage. This advantage stems from the fact that hydraulic turbines used to generate power are capable of almost instantaneously supplying power to meet a demand while a steam generating unit must be heated up slowly before it can supply power. This ability to meet a demand the instant it occurs is vital in peaking power supply, because peak demands can occur with little notice and a supply must be available. The only way steam units can meet this type of demand is by being kept on what is called "spinning reserve". This condition requires that boilers be kept hot and the unit working in anticipation of a peak demand. There is no power produced and fuel is consumed and theoperation is uneconomical if other alternatives exist. It must also be considered that this would probably occur to the less efficient thermal plants which again is costly. Also to be remembered is the fact that the fuel for a hydroelectric plant, water, has no cost. From this it is seen that steam or nuclear plant generation is best adapted to meet base load demands where it is desirable that a unit produce power at a given rate continuously and hydro to meeting peak demands with sudden and sharp variations. Again the hydro plant is the least pollutant producer of all plants.

Hydro does however have negative factors. Its initial cost is expensive, although nuclear continues to escalate. The site of a hydro plant will rarely be close to the demand whereas other modes, excluding pumped storage, can be so located. This site distance can induce costly transmission systems. The environmental factors due to areal extent of hydro development can be of major significance.

CHAPTER II

POWER LOADS AND UNDEVELOPED HYDRO

The NEPOOL Planning Committee, on 11 February 1976, issued a report entitled, "New England Load and Capacity Report, 1976-1986". This report provides an excellent backdrop presenting peak loads, capacities and mixes. It states that the average compound growth forecast for investor facilities is 5.6% for the next decade, for both winter and summer peak loads whereas prior to the energy crisis, the average annual growth rates were 7.4% (winter) and 8.9% (summer) during the 1963-1973 period. This change is probably attributed to the effects of use conservation and the present overall distressed economic conditions.

The mix of generating facilities of investor-owned facilities is shown in Table I on page 13.

Several important facts develop in the next decade from the above data:

(1) Projected peak load will increase 72.9%.

(2) Projected increase in capability will be 39.4%. This incompatibility with peak increase is due to present reserve after maintenance of 45.4%, which will reduce in 1986/87.

TABLE I
NEW ENGLAND POWER LOAD
(IN MEGAWATTS)

		Winter Season 1976/77	Winter Season 1986/87 (3)
I	Total Peak Load	14,518 (1)	25,105
II	Conventional Thermal	12,468	13,062
	Nuclear Capability	4,231	12,371
	Gas Turbine	1,489	1,609
	Combined Cycle	205	475
	Diesel	243	243
	Hydro	1,287	1,284
	Pumped Storage	1,632	1,632
	Purchase outside New England	594	205
	Total Capability	22,148	30,881 (2)

(1) The 1975/76 winter peak of 13,908 MW occurred on January 22, 1976, hour ending 1800.

(2) Only "NEPOOL Planned Units" are included; however, additional units are under study and in the planning stage.

(3) Represents the net change in generating capability.

(3) There is a relatively minor increase in conventional thermal capability - 4.8%.

(4) There is a significant increase in nuclear capability - 192%. Whereas today it represents 19% of the total capability, in 1986/87 it is scheduled for 40% of then total.

(5) There is no scheduled increase in either conventional hydro or pumped storage.

(6) Hydro in 1976/77 represents 5.8% of the total capability and in 1986-87 will be 4.2%.

(7) Pumped storage in 1976/77 represents 7.4% of the total capability and in 1986/87 will be 5.3%.

Probably the most significant fact of the growth proposal is that the substitution of hydro for thermal (oil fired) plants may mean the elimination from service of low efficiency thermal plants with capital investment loss. We must further keep in mind that the modes of operation are dissimilar and do not necessarily make them interchangeable as discussed earlier.

Addressing the subject of conventional hydropower, the Federal Power Commission in a report dated 1 January 1972, states that the installed capacity for New England is 1,510,783 KW.

It also states that there is a potential of 93 undeveloped sites and a capacity of 3,318,153 KW. However, in accepting this latter capacity, it must be noted that the report stated "Many of the sites have not been analyzed in sufficient detail to evaluate their economic or environmental costs and benefits, but are included to give the reader an indication of the upper limit of conventional water power potential".

This led to a review of the New England, New York, Interagency Committee Report on Natural Resources of 1955. That report reviewed some 1200 potential power sites. This was narrowed down to 49 sites with a potential capacity of 1,867,000 KW. Those selected had a benefit to cost ratio (economic yardstick) of 0.6 to 1.0 or better. If you add the Dickey-Lincoln School Project (830,000 KW) to this, as it had not been included, it yields a figure of 2,687,000 KW. This compares to the FPC figure of 3,318,153 KW. As the projects of the NENYIAC Study had made in-depth technical and economic analyses of the candidates it was deemed reasonable to use them as a basis of analysis. It should be noted that the early studies did not significantly reflect the environement criteria that exists today. This has major significance in today's world. (An Environmental Impact Statement for Dickey-Lincoln School is costing $900,000.)

The committee then took this base and updated the construction costs to 1 January 1976 and received comparably timed power costs from the Federal Power Commission so that a current benefit/cost ratio could be established. This exercise resulted in 9 projects with a total capacity of 1,220,000 KW having a benefit/cost ratio in excess of unity, and 9 projects with a total capacity of 585,000 KW with a benefit/cost ratio of 0.8 to 1.0 to unity. In toto it adds to 1,805,000 KW of undeveloped power. Transmission costs were not included. This feature requires an extensive in-depth coordinated study with the Federal Power Commission and the private-investor electric companies of New England and can have substantial dollar cost. Pertinent figures are shown on Tables II and III. It is interesting to note the cost if all were implemented: B/C ratio equal to better than unity $820,911,000; B/C ratio 0.8 to 1.0 to unity - $613,815,000. A grand total of 1,805,000 KW @ $1,434,726,000. The location of the potential hydro sites are shown on Plates III and IV.

It is interesting to note the distribution of location of potential hydro siting:

STATE	CAPACITY (KW)	COST ($1,000)
Maine (10)	1,505,000	$ 1,089,686
New Hampshire (6)	210,000	221,363
Vermont (0)	-	-
Massachusetts (1)	30,000	29,310
Rhode Island (0)	-	-
Connecticut (1)	60,000	94,367
TOTAL	1,805,000	$ 1,434,726

TABLE II - B/C RATIO EXCEEDS UNITY

BASIN/RIVER	PROJECT	INSTALLED CAP. KW	CAPACITY FACTOR	AVERAGE ANNUAL OUTPUT (1,000 KWH)	CAPACITY BENEFIT ($1,000)	ENERGY BENEFIT ($1,000)	TOTAL BENEFIT ($1,000)	INITIAL COST ($1,000)	ANNUAL COST ($1,000)	B/C RATIO
ST. JOHN										
ST. JOHN	DICKEY	760,000 (8)	.11	849,000	$22,204 1/	$34,345 1/, 2/	$58,949 3/	$463,000	22,850	2.61
ST. JOHN	LINCOLN SCHOOL	70,000 (2)	.37	305,000						
PENOBSCOT										
W. BRANCH	ARCHES	50,000	.21	94,250	1,400	2,074	3,747	34,207	2,854	1.22
PENOBSCOT	BASIN MILLS	50,000	.21	93,150	2,100	2,096	4,196	46,993	3,600	1.17
KENNEBEC										
KENNEBEC	MADISON (HIGH DAM)	80,000	.21	146,800	2,600	3,155	5,756	48,871	3,855	1.49
ANDROSCOGGIN										
MAGALLOWAY	AZISCOKOS	25,000	.22	49,080	700	1,080	1,780	11,875	1,100	1.62
ANDROSCOGGIN	PONTOOK	50,000	.20	88,410	1,825	1,945	3,770	40,560	3,153	1.20
ANDROSCOGGIN	PULSIFER RIPS	25,000	.19	42,640	950	959	1,909	24,799	1,919	1.00
MERRIMACK										
MERRIMACK	MOORES FALLS	50,000	.20	101,000	2,100	2,272	4,372	56,239	4,349	1.00
CONNECTICUT										
CONNECTICUT	ENFIELD	60,000	.50	261,900	2,520	6,940	9,460	94,367	7,534	1.26
TOTAL		1,220,000		2,031,230				$820,911		

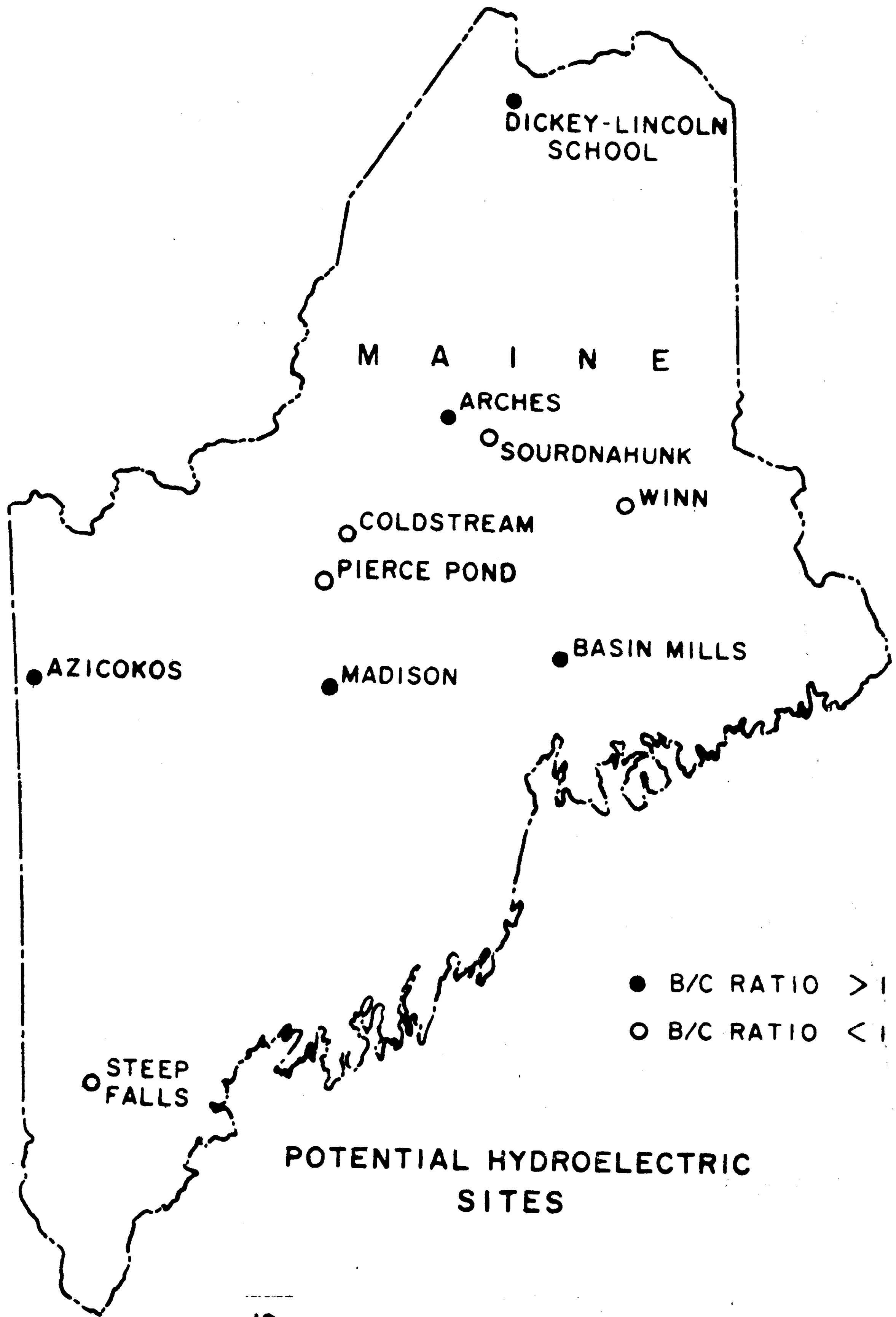
1/ At market values used for capacity and energy benefits.

2/ Includes downstream energy benefit of $3,500,000. (350,000,000 KWH)

3/ Includes flood control, recreation and redevelopment benefits. (5% ±)

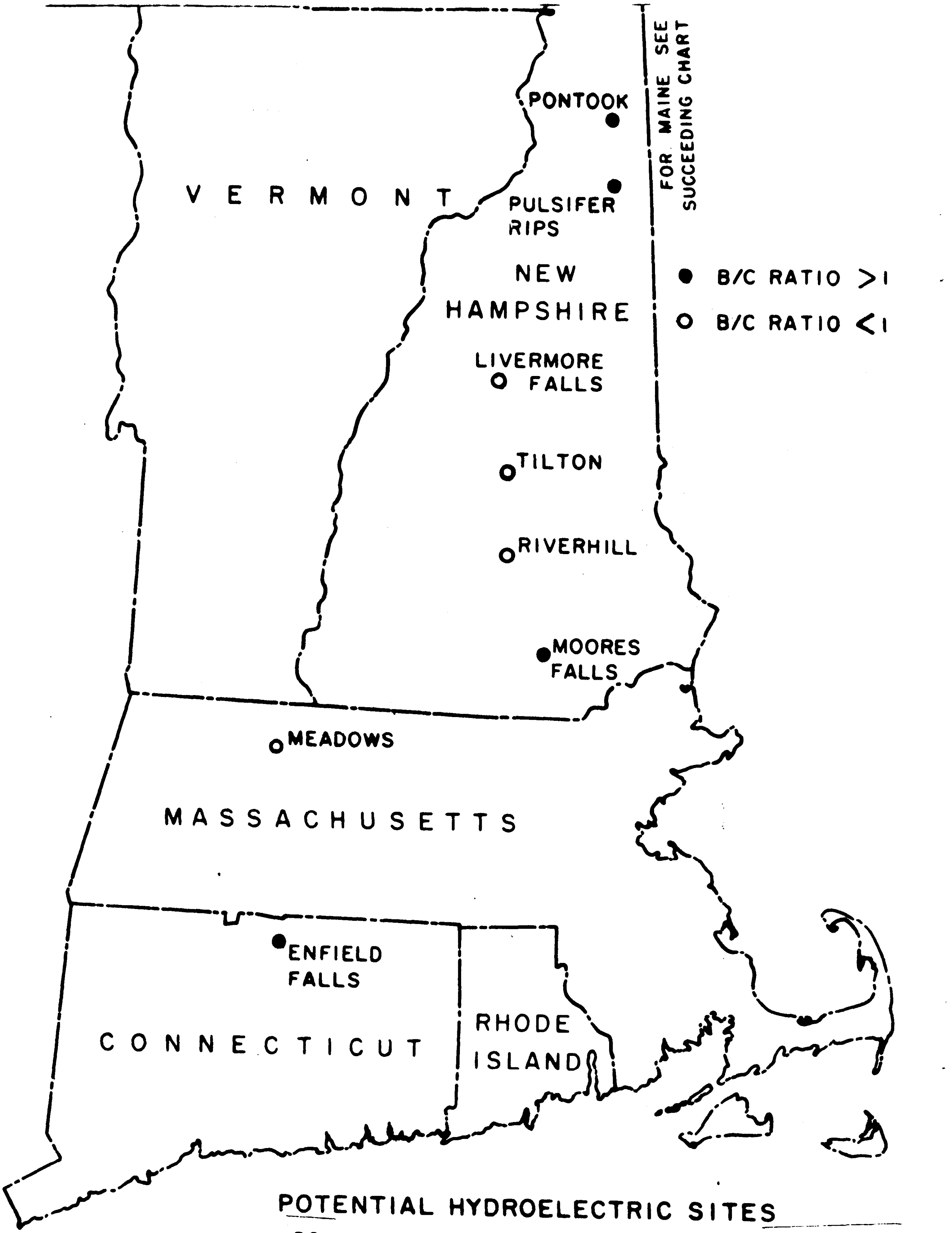
TABLE III - B/C RATIO 0.8 to 1.0/UNITY

BASIN/RIVER	PROJECT	INSTALLED CAP. KW	CAPACITY FACTOR	AVERAGE ANNUAL OUTPUT (1,000 KWH)	CAPACITY BENEFIT ($1,000)	ENERGY BENEFIT ($1,000)	TOTAL BENEFIT ($1,000)	INITIAL COST ($1,000)	ANNUAL COST ($1,000)	B/C RATIO
PENOBSCOT										
WEST BRANCH	SOURDNAHUNK	50,000	.23	109,450	$ 1,475	$ 2,517	$ 3,992	$ 54,588	$ 4,283	.93
PENOBSCOT	WINN	50,000	.20	89,170	1,600	1,962	3,562	54,749	4,155	.86
KENNEBEC										
KENNEBEC	COLD STREAM	120,000	.25	259,350	3,480	5,835	9,315	125,597	10,098	.92
PIERCE POND STR	PIERCE POND	220,000	.23	459,000	5,830	9,900	15,730	217,154	17,764	.88
SACO										
SACO	STEEP FALLS	30,000	.18	47,690	1,110	1,025	2,135	32,652	2,650	.81
MERRIMACK										
PEMIGEWASSET	LIVERMORE FALLS	35,000	.23	69,800	1,278	1,605	2,883	44,295	3,544	.81
WINNIPESAUKEE	TILTON	20,000	.17	29,600	650	607	1,257	15,969	1,327	.95
CONTOOCOOK	RIVER HILL	30,000	.24	63,700	1,170	1,497	2,667	39,501	3,186	.84
CONNECTICUT										
DEERFIELD	MEADOWS	30,000	.16	41,800	1,230	857	2.087	29,310	2,381	.88
TOTAL		585,000		1,169,560				$613,815		
TOTAL TABLES I & II		1,805,000		3,200,790				$1,434,726		



POTENTIAL HYDROELECTRIC SITES

PLATE III



POTENTIAL HYDROELECTRIC SITES

PLATE IV

This emphasizes the fact that the sites are not in general proximity to the power loads and will lead to extensive transmission systems not treated in this paper due to lengthy and costly complex studies required to assay same (including environmental studies).

A review of the projections of the investor-owned facilities for the next decade and the potentially undeveloped hydro sites elicits a major arena for the decision maker, especially in the field of economics, in determining the development of hydro power for electric power generation. Representatives of the in-put to the decision-maker are the following:

1) Present plants of the investor-owned utilities is that % reserve after maintenance will reduce from 45.5% or 6517 MW to about 16% or 5000 MW, in the next decade.

2) An inspection of Tables II and III indicates that the total potential hydro capacity is 1805 MW and the plant factor for proposed hydro plants lies generally between 15% to 25%. This shows their best integration is for peaking power.

3) Of the contemplated investor-owned facility growth of 8,733 MW in the next decade, 8,140 MW or 93% is proposed to be nuclear whose true benefit is high load factor base load.

4) To meet the 25,105 MW winter peak load in 1986/87, 5448 MW of peaking capacity is programmed. In the same decade

only 390 MW of new peaking capacity will be added. During this same period purchases will decline by 389 MW. It becomes apparent, therefore, that the decade's increase in peaking requirements can only be met by the use of older, low efficiency, and high fuel consumption thermal units.

5) If the 1805 MW of projected hydro was fully developed then it could conceivably replace the equivalent amount of older thermal capacity.

6) And always must be borne in mind that thermal and hydro are not directly interchangeable. Thermal can theoretically operate for extended periods, assuming fuel is available, and making allowance for plant efficiency, at 100% plant factor. Hydro would operate at a markedly less plant factor.

7) Hydro will reduce the use of petroleum as a fuel source but at what net overall cost?

8) Who will be the decision makers and who will finance the cost of hydro if it is a viable alternative?

Since the completion of this Chapter, further figures have surfaced that indicate the projected generating capacity, peak load and margin for 1995 (winter) will grow to:

Total controlled net capability	51,042 MW
Coincident peak load	40,995 MW
Gross Margin	10,260 MW
Gross Margin - % of load	25.0%

Percentage of capability addition in 10 year period 1986-1995:

Fossil Fuel	15.6%
Nuclear	66.8%
Hydro	17.6%

It is likely that the hydro growth may be pumped storage in the 1990 frame and placed after development of nuclear.

(SUPPLEMENT)

CHAPTER III

PUMPED STORAGE

Conventional hydroelectric developments utilize the energy of falling water in rivers and streams to produce electric energy. Pumped storage developments employ the same principle for the generating phase, but all or part of the water is made available for reuse by pumping it by mechanical means from a lower to an upper pool.

There are two major categories of pumped storage projects: (1) developments which produce energy only from water that has previously been pumped to an upper reservoir, and (2) developments which use both pumped water and natural runoff for generation. Although pumped storage projects may have conventional hydroelectric generating units and separate pumps, most developments utilize reversible, pump-turbine units. Some plants contain both conventional and reversible units.

A pumped storage plant has the same favorable operating characteristics as a conventional hydroelectric plant - rapid start-up and loading, long life, low operating and maintenance costs, and low outage rates. The ability of a pumped storage plant to accept or reject large blocks of load very quickly makes it much more flexible than a steam-electric plant, for system load fluctuations. The ability to follow system load variations allows for the more uniform and efficient loading of the base load capacity. Also by pumping in the off-peak hours, the plant factor of the base load thermal units is improved thus reducing cycling of these units thereby improving their efficiency. Because of losses in the pumping-generating cycle, pumped storage plants require approximately three kilowatt-hours of pumping energy to provide two kilowatts of generation. Therefore, the availability of a dependable supply of low cost pumping energy is essential.

The time of the pumping cycle may be as much as 1-1/2 times that of the generation cycle with units operating at full load, a daily pumping cycle of 8 to 10 hours would assure only about six hours of generation per day. Normally, therefore, it is necessary to construct reservoirs with adequate storage capacity to permit operation on a weekly cycle with additional pumping over weekends. Storage capacities should be large enough to assure dependable operation under the most adverse load conditions. With this in mind and considering peak load conditions, reservoirs should have sufficient storage capacity to permit from 12 to 20 hours of continuous full load conditions.

The usual practice is to use new efficient steam-electric units, either fossil-fueled or nuclear, to serve the base portion of the utility load. The less efficient steam-electric capacity usually the older equipment (almost always fossil fueled) is used to serve the higher portions of the load and therefore operates at a lower capacity factor. Normally, conventional hydroelectric and pumped storage plants along with gas turbines, are employed in serving peak portions of the load. In some cases the conventional hydroelectric plants will operate at high capacity factors because the rate of flow releases must be relatively constant in the interest of navigation and downstream users. Run-of-river projects usually operate at high capacity factors during periods when available stream flows permit. The cost of nuclear generation decreases at high load factors due to the reduction in fuel costs as a share of plant operation. Thus, in New England it is the preferred alternative for high utilization base load duty. Cycling fossil plants have the lowest production costs for load factors in the 25 to 65 percent range and are therefore the preferred alternative for the intermediate range of load. Pumped storage and gas turbines provide the lowest costs at very low load factors, and are therefore the preferred alternative for peaking duty. Economic use of pumped storage is greatly enhanced by the availability for the pumping cycle of energy which has a low incremental cost. Therefore, pumped storage becomes more economical in a mix with a high proportion of nuclear generation.

The New England River Basins Commission in July 1973 issued a report entitled "An Environmental Reconnaissance of Alternative Pumped Storage Sites in New England" prepared by an ad hoc Power and Environmental Committee. The Committee started with a list of 52 alternative, technically feasible pumped storage sites in New England. The first evaluation step was a screening process in which the number of sites was reduced from 52 to 14. Screening was carried out with two criteria: insufficient generating capacity (less than 1,000 MW) and obvious and unacceptable environmental impacts. The 14 sites were further evaluated, including site visits, resulting in the grouping of the sites into three categories:

(1) those involving the least amount of on-site environmental impact (Great Barrington #2, Mass.; Fall Mountain, N.H.; Percy #3, N.H.; Site Leo, Me.);

(2) sites with the most on-site impacts (Schenob Brook, Mass.; Middlebury, Vt.) and

(3) sites with an intermediate amount of on-site impact (Canaan Mt., Conn.; Monterey, Mass.; Tolland Center, Mass.; West Rumney, N.H.; Bingham #3, Me.; Robinson Pond, Me.). Details and locations are shown on the following table and plate. It is noted that their is a difference between the figures of NEPLAN and NERBC as the latter has optimized development. In either case, both determinations indicate an abundance of capability. Ultimate selection on sites to be developed, if so elected, will require much detailed study considering many factors e.g. cost, usability, transmission, and system integration.

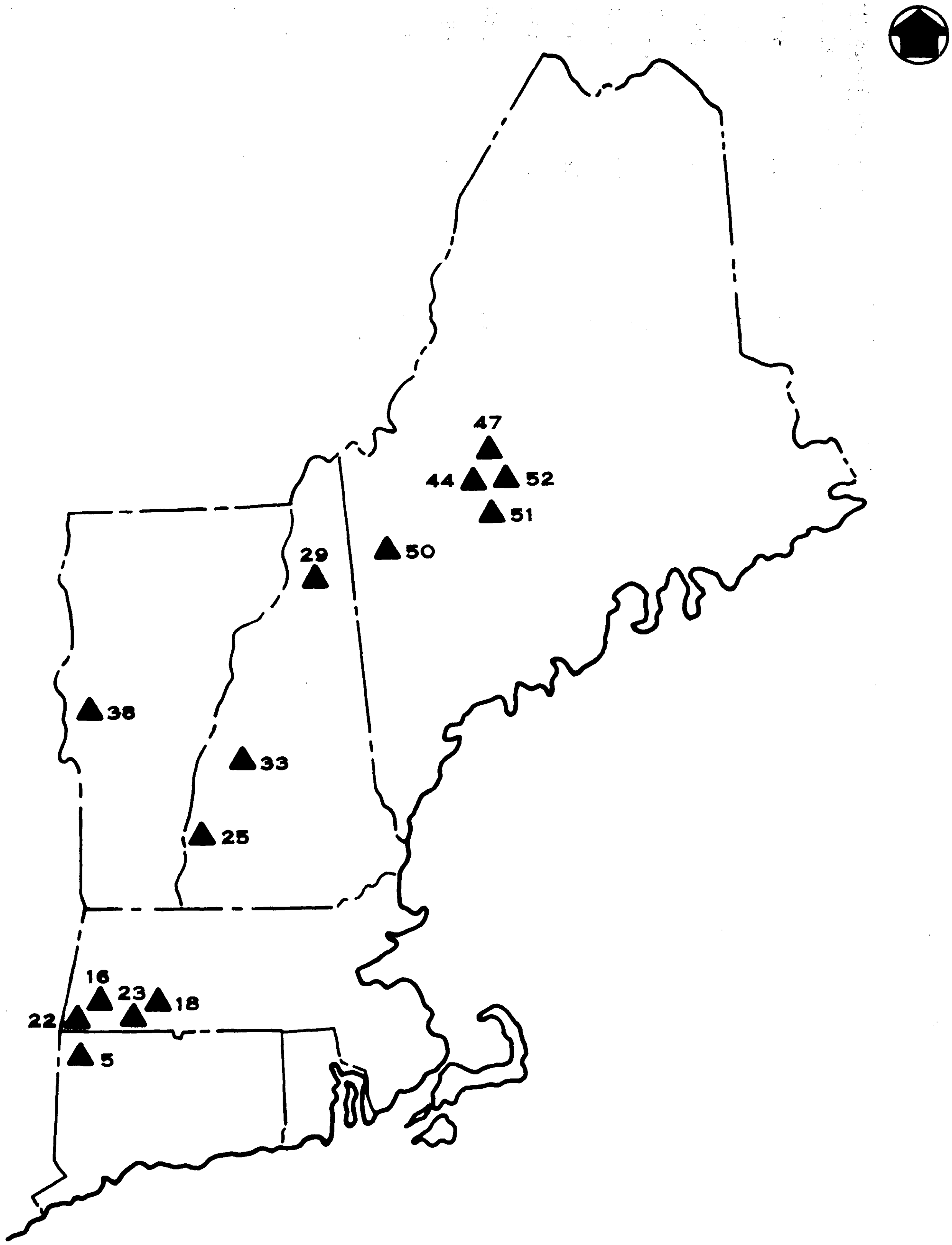
TABLE IV. Comparison of Data Supplied by Industry with That Used by Task Force in Making Site Evaluations

Site	Capacity (Mw)		Reservoir Size (Acres) Upper Pool		Reservoir Size (Acres) Lower Pool		Average Head (ft)	
	NEPLAN	Task Force 1/	NEPLAN	Task Force	NEPLAN	Task Force	NEPLAN	Task Forc
Canaan Mtn.	2,000	2,000	720	720	750	750	880	880
Gt. Barrington	900	1,300	215	226	625	650	772	790
Monterey	1,600	2,900	412	460	892	640	825	840
Schenob Brook	2,000	1,000	330	330	2,925	2,925	1,118	1,070
Tolland Center	1,000	1,300	406	800	725	-- 2/	720	660
Fall Mtn.	800	1,000	260	215	2,800	-- 2/	665	663
Percy #3	1,900	3,400	530	620	920	920	880	890
West Rumney	1,000	1,500	174	190	305	450	1,205	1,220
Middlebury	1,200	1,200	315	275	1,180	900	1,193	1,189
Bingham #3	1,000	1,900	270	270	3,200	-- 2/	863	900
Site Leo	1,000	1,450	185	185	3,200	-- 2/	847	856
Oquossoc	1,000	5,300	800	800	7,600	-- 2/	524	515
Pleasant Ridge	1,900	1,900	800	800	3,200	-- 2/	790	820
Robinson Pond	2,000	7,930	1,440	1,440	3,200	-- 2/	806	781

1/ Maximum developable capacity.

2/ Lower pool already exists.

* The differences between Task Force and NEPLAN data shown in this table are essentially differences in the initial concepts of the sites held by the two groups. These differences extend to such things as the exact layout of the pools, configuration of dikes, dams and tunnels, initial practicable versus ultimate developable capacity, and so on. These differences are not significant enough to affect the reconnaissance type of environmental evaluation conducted in this study.



APPROXIMATE LOCATION OF PUMPED STORAGE SITES REMAINING AFTER PRELIMINARY SCREENING

PLATE V

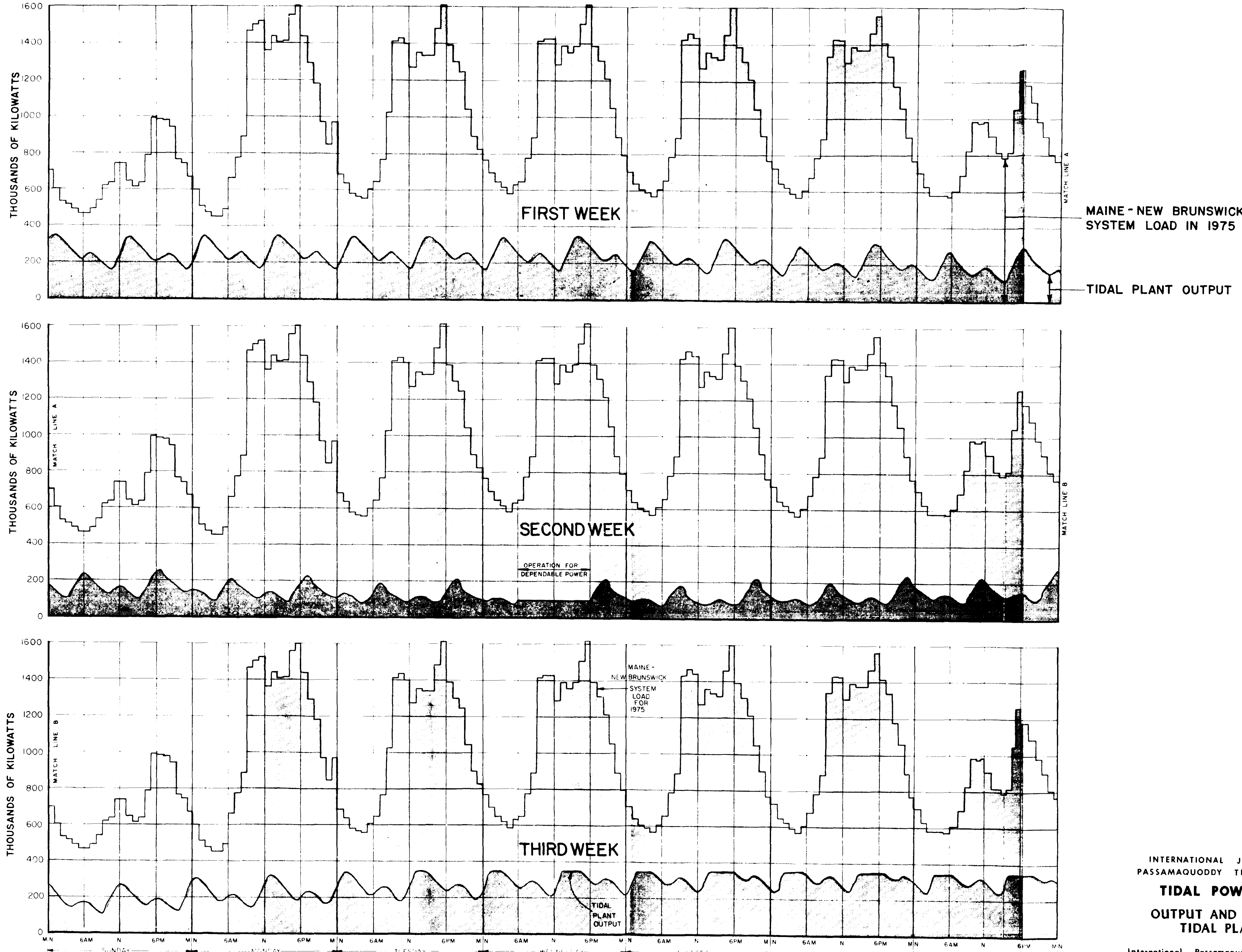
CHAPTER IV
TIDAL POWER

Aside from conventional hydropower and pumped storage, a remaining source of hydropower is the obtaining of electric power from the tides. This method is of long standing dating back to the 11th century where one finds tidal plants in Great Britain, France, Spain, and other countries. The average size plant ran from 30 to 100 KW; and was largely used to grind corn , wheat, and similar grains i.e. a mechanical power converter rather than electrical. However, most of these plants were phased out by the end of the 19th century due to power economics, that is the development of hydro and thermal plants provided cheaper and more ready power.

However, the escalating cost of fuel has directed attention to its viability in today's market. New England is singularly fortunate in having one of the few technically feasible sites in the world. A tidal plant is normally a low head project but with a large conservation pool of predictable storage. The New England site is well known in the energy field as the Passamaquoddy Tidal Power project. Located in the vicinity of Eastport, Maine, it is a two pool scheme with a high pool in Passamaquoddy Bay and a low pool in Cobscook Bay. In simplicity, the high pool is filled on a rising tide through a bank of open filling gates. When the tide reaches its peak the filling gates are closed and the bay storage entrapped. During this cycle the gates of the low pool remain closed resulting in an elevation difference between the two pool levels - this forms a head. On the falling tide the water from the high pool flows through a power house between the two pools into the low pool thus generating electrical power. At a propitious moment the emptying gates of the lower pool are opened thus evacuating the low pool. The gates are then closed, and the cycling process repeated.

Passamaquoddy has a tidal level varying between 11.3 feet on a neap tide and 25.7 feet on a spring tide with an average tide of 18.1 feet. Its great asset is the tremendous volume of water coursing in and out of the Bay of Fundy twice a day. This amounts to 4 billion tons of water. This is equivalent to a two week flow of the Mississippi River above New Orleans which equals the accumulated runoff of almost one-half of the total 3 million square mile land area of the United States of America.

However, in spite of all the assets and predictability of same of a tidal plant it does have drawbacks. One of these is that the plant output fluctuates and thus rarely meets the load pattern of the system. This is seen on the accompanying two charts. The cause is the variation in head between neap and spring



INTERNATIONAL JOINT COMMISSION
PASSAMAQUODDY TIDAL POWER SURVEY

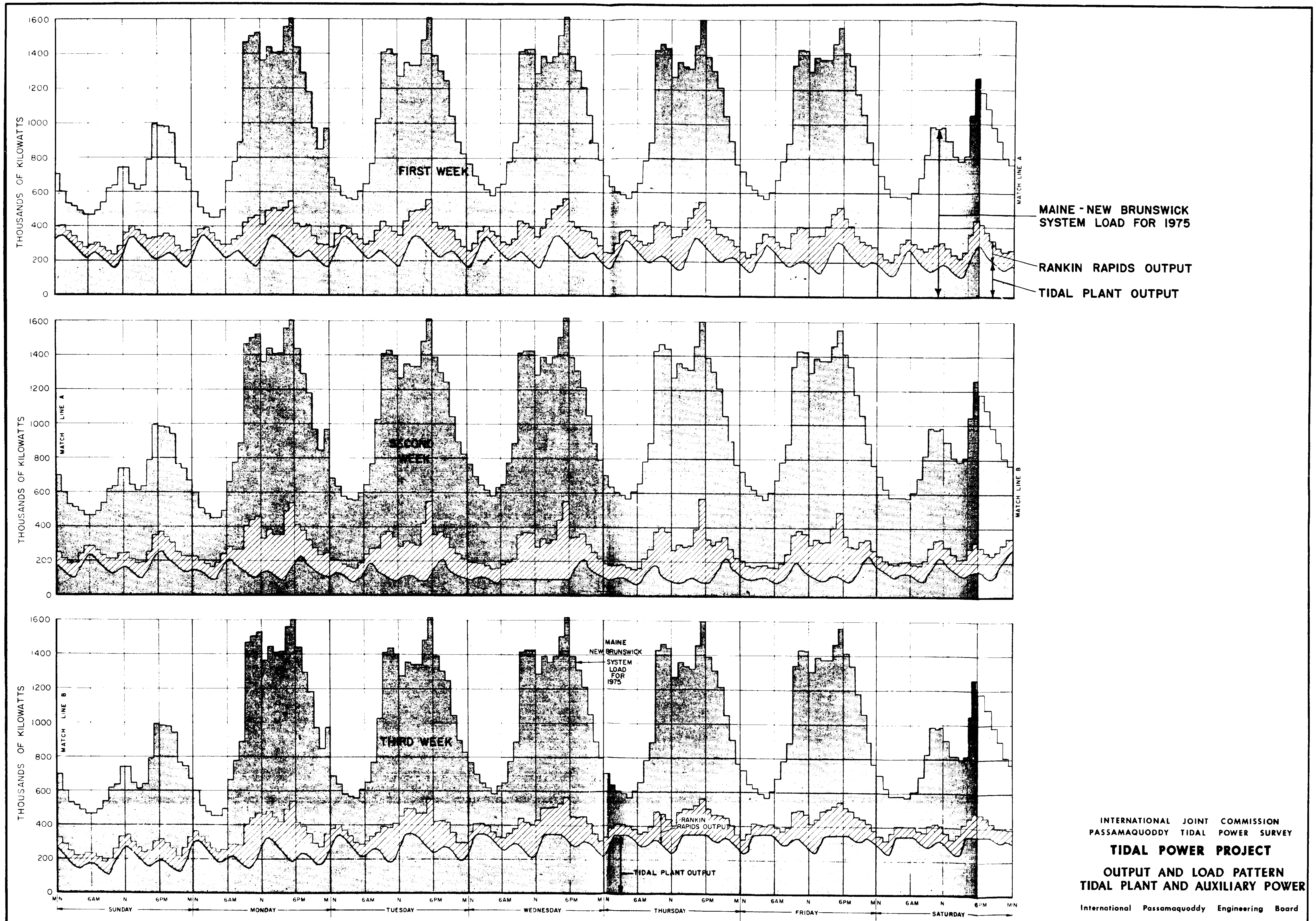
TIDAL POWER PROJECT

OUTPUT AND LOAD PATTERN
TIDAL PLANT ALONE

International Passamaquoddy Engineering Board

AUGUST 1959 Dwg No TG7 - 226

PLATE VI



INTERNATIONAL JOINT COMMISSION
PASSAMAQUODDY TIDAL POWER SURVEY

TIDAL POWER PROJECT

OUTPUT AND LOAD PATTERN
TIDAL PLANT AND AUXILIARY POWER

International Passamaquoddy Engineering Board

AUGUST 1959 Dwg No TG7-229

PLATE VII

tide as shown above and the fact that there is a 50 minute lag in the tide each day. Thus the maximum plant output is rarely synchronous with the load pattern. This can be regulated by combining an auxiliary power source with the Passamaquoddy plant such as a river hydro plant, a pumped storage plant, a thermal plant, gas turbines, etc. However, this adds cost to the total project.

Passamaquoddy has been studied since the 1930's. An initial start of construction was made in the mid-1930's but stopped in a short time. Studies of varying magnitudes continued and although each proved the technical feasibility the project failed to meet financial criteria and acceptance. The project as last envisioned in 1964 would be a 500 MW installation (expansible to 1000 MW) and would generate 1.9 billion KWH per year. Using updated figures as of July 1974, the project would approximate $1 billion in cost. Its benefit to cost ratio was well less than unity.

The Congress, conscious of the impact of the oil problem on energy producing plants and aware of the potentialities of tidal power have recently directed a relook of Passamaquoddy as to financial feasibility today. The New England Division, Corps of Engineers in association with the Federal Power Commission, is presently undertaking a review of present construction costs and power benefits to establish a current financial picture. This will hopefully be ascertained by November 1976. As the same time, the Energy Research Development Administration is pursuing studies including recent developments in the state of the art particularly as to turbine-generator developments and construction methods for structures (directed towards reducing project costs.) Completion date for this study is January 1977. Both studies will be closely coordinated during progress to obtain and present the best posture.

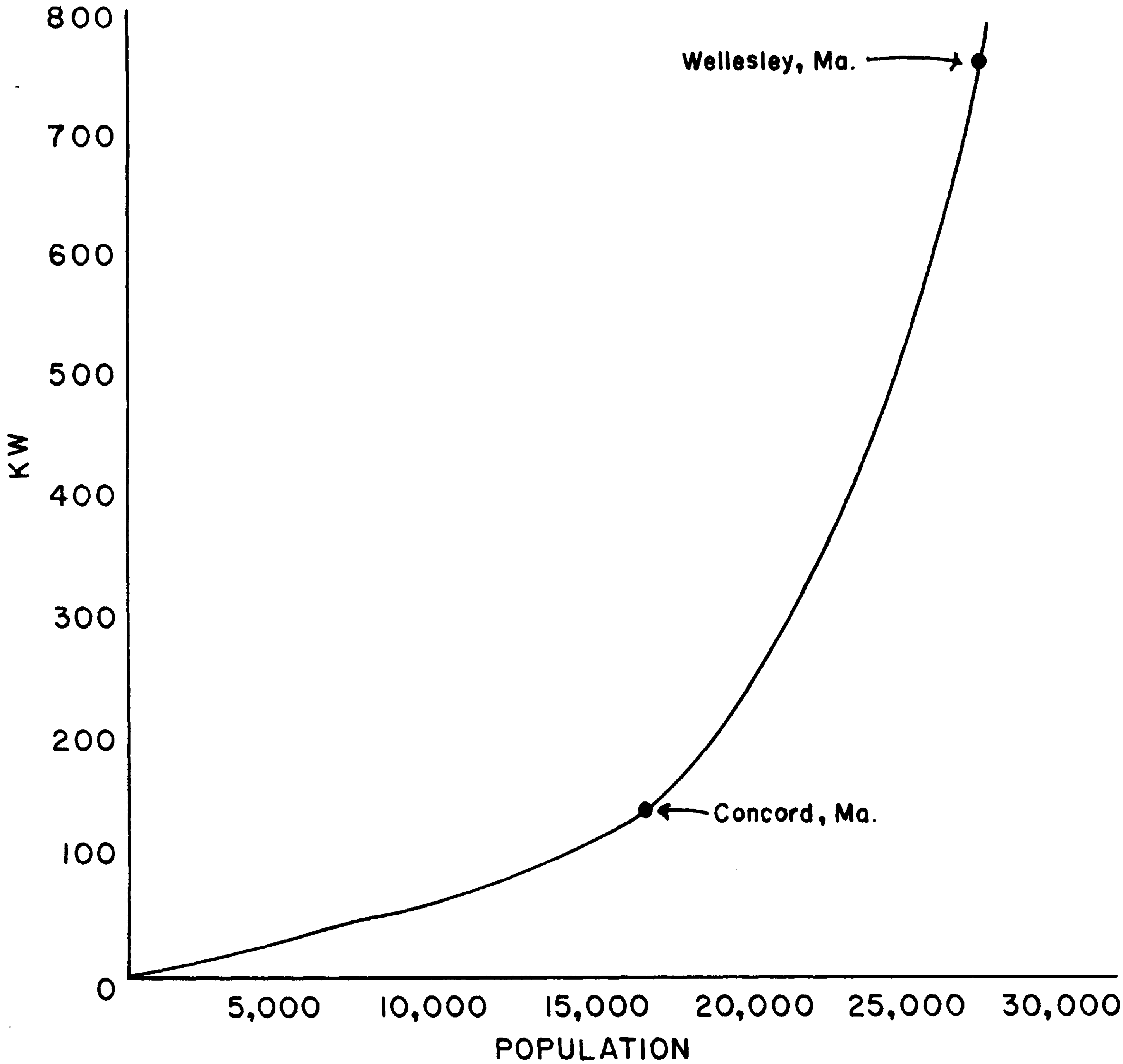
In addition to the major Passamaquoddy Tidal project, the Passamaquoddy Indian Tribe has proposed a smaller tidal project of 2000 KW utilizing Bar Harbor Cove. This area is a part of the major project and could be developed without interference or impact on the major project. They would use the developed energy for the tribal reservation and also use the project for mariculture development. The project has been estimated to cost between $5 and $6 million dollars. The project is now under study by the Passamaquoddy Indian Tribe.

CHAPTER V
SMALL HYDRO SITES

As the center of industrial development dating to Colonial days, water power has been used in New England for conversion to both mechanical and electrical power. This has been evidenced by a recent inventory performed by the Corps of Engineers in connection with a broader program of dam safety. Using the criteria of a minimum height of six feet or a storage capacity of 50 acre-feet, it developed that there are existing 3,000 dams. Some dams are in good repair - many are in varying degrees of disrepair. Although the directive mentioned did not include a survey of power potential or whether the project had been so used, information was gathered showing that possibly 20 to 30% have at one time or another been used for power generation. Much of the equipment is either missing or in unusable condition, and in some cases waterways have been cemented in and all of the equipment removed. As a rule, the installations were small varying from 50 to 500 KW. Storage pools were small making the plant a run-of-river and resulting in varying outputs both seasonably and even daily.

There has been a growing interest in the revitalization of these small dams due to the high electric rates in New England and continuing fear of continued escalation of oil prices. Although the number of dams is large, the collective total capacity potential is small. It is unlikely that the 20/30% would hold up economically today. Assuming that for financial, environmental or other factors that the number for consideration would be 15% or 450 and that the average size plant be 400 KW this would yield 180,000 KW (180 MW). Although small total systemwise if developed the plant could have significant advantages especially to the smaller communities. The power generated could be utilized during peak load periods (the most expensive electricity), for street lighting (see Plate VIII); lighting and equipment operation in community facilities e.g. town hall, school, athletic facilities, light industries, etc.

To explore the total number of potentials for restoration or creation is an extensive and costly undertaking. It has been proposed that a more expeditious method might be the selecting of a site in each New England state, each site having different characteristics and exploring them thoroughly. A handbook could then be developed on said restorations for use by those communities to determine if they have a continuing interest. The book would show typical methods of restoration, cost factors, hydrologic data, capacity and energy,



STREET LIGHTING LOAD IN KW

PLATE VIII

environmental factors and guides, licensing, hopefully funding procedures, and other helpful data.

There are many factors that will also require investigation:

1) Integration with the private-investor utility for backup at low flow periods or breakdowns.

2) Possible sale of excess energy to private-investor owned facilities.

3) Use of distribution system if owned by others.

4) Potential development of package turbine-generator unit as used in European countries.

5) Project financing - Federal, State, Community, Private individual, cost-sharing.

The Mitre Corporation has made an investigation of the restoration of a site in Wareham, Massachusetts. The reader is referred to this report treating of the subject. The States of Vermont and Rhode Island have expressed an interest, as well as private individuals and companies.

Again, although collectively not proportionately substantial, the restoration of small dams should not be ignored. It has meritorious features, even though fraught with many drawbacks, and it is recommended that a study be undertaken to determine their practicality as an alternative to the addition of fuel burning plants.

CHAPTER VI

LICENSING

Part I of the Federal Power Act empowers the Federal Power Commission to issue licenses for periods not exceeding 50 years to citizens, corporations, cooperatives, States, and municipalities authorizing the construction, operation and maintenance of water power projects on navigable waterways, on streams which Congress has jurisdiction, where the project affects interstate commerce or on public lands or reservations of the United States. Licenses may also be issued to such non-federal interests to utilize surplus water or water power from government dams.

The Commission may also issue preliminary permits for a three year period for the purpose of giving applicants priority in applying for licenses while making examinations and surveys of proposed developments. An important provision of the "Act" is the requirement in Section 10(a) that any hydroelectric project licensed shall, in the judgement of the Commission, be best adapted to a comprehensive plan for the development and utilization of the water resources of the river basin for all beneficial purposes, including recreation.

In order to obtain a license for the construction and operation of a hydroelectric project an applicant must furnish statements and exhibits as specified in the Commission Regulations Title 18 - Chapter I of the Code of Federal Regulations: "Conservation of Power and Water Resources." Required information includes descriptions of the project and project works, maps and drawings of project facilities, the scope of the development, construction scheduling, capacity and estimated generation of the facility, project land owned and to be purchased, land affected by the project and project costs. Statements are required indicating the proposed use or market for the project power or how the project will be utilized. The applicant must also include information on its corporate or organizational structure, copies of State laws pertaining to the project, compliance with State water rights, and financial responsibility for the project. In addition proposed operation of the project must be given in detail, information of low, normal and flood flows of the stream, minimum flow releases and planned use of the project for ancillary purposes such as navigation, irrigation, flood control or municipal water supply.

A proposed plan for full public utilization of project water and adjacent lands for recreational purposes is required, as well as a report on the effect of the project on fish and wildlife resources and proposals for measures necessary to conserve and, if practicable, to enhance fish and wildlife resources affected by the project. Descriptions of any properties listed in the national register of historical or archeological sites which might be affected by the project are required by the Commission. The applicant is required to furnish a summary of the efforts to protect and enhance natural, historic, scenic and recreational values in locating associated facilities such as rights-of-way and transmission lines. Applicant must also prepare a detailed statement including a summary of the environmental factors relating to the five points specified in the National Environmental Policy Act of 1969.

When an application for a license or license amendment is received comments are requested from appropriate Federal and State agencies having jurisdiction. Each proposed project is evaluated by the Commission staff for safety and adequacy, economic feasibility and adaptability to a comprehensive plan. Hearings are held if necessary, to ensure that a complete record is available on relevent issues involved in the licensing action. All licenses issued by the Commission contain standard construction and operating requirements and, where deemed necessary, include a separate environmental impact statement prepared by Commission staff. These requirements assure optimum development of sites and guarantees conservation of resources and preservation of the environment. These safeguards may, in some instances, result in licensing delays.

As of December 31, 1975 there were 106 constructed conventional hydroelectric plants operating under Federal Power licenses in New England. The almost 1,200 megawatts installed in these plants represented about 77% of the total developed hydroelectricity capacity in the area. Forty-five constructed projects with an aggregate capacity of almost 189 megawatts had license applications pending.

Three pumped storage were in operation, two of which are licensed: Northfield Mt. (1,000 megawatts) and Bear Swamp (600 megawatts). The third project, Rocky River, has 7 megawatts of reversible capacity of a total 31 megawatt installation.

The New England Power Pool indicates a total dependable hydroelectric capability of 1288 megawatts at the end of 1975, representing about 6.5% of the total dependable capability in New England. In addition dependable pumped storage capability was 1632 megawatts or 8.2% of the total dependable capability. Only one hydroelectric plant is indicated as scheduled for construction in the 1975-1986 time frame, the 12 megawatt Brunswick/Topsham project of Central Maine Power Company. No new pumped storage facilities are indicated. Total peaking capacity, which includes gas turbines, combined cycle, diesel, hydroelectric and pumped storage are expected to decline from 23.7% to 17.1% through the ten year time frame. It appears that small amounts of hydroelectric capacity could easily be absorbed and utilized for peaking purposes unless there is a drastic change in the shape of the load curve.

There are a number of hydroelectric projects in New Hampshire and Vermont that are in various stages of investigation by private and municipal groups. Six projects under active consideration have a combined capacity of 142.5 megawatts, or less than 1% of present installed capability.

Of the 102 constructed projects operating without licenses, many are very small and are owned by industrial companies. In addition to the projects totalled, many others have been abandoned or have had their generating equipment removed. Rehabilitation of these projects seems unlikely at this time due to the high cost of redevelopment or modernization. Past experience has shown that many of the sites with small potential installations have low benefit-cost ratios. If construction and operating (including fuel) costs continue to escalate it appears likely that many of these sites should be re-evaluated. However, it is still very possible that conclusions reached previously will continue to be valid.

TABLE V

CONVENTIONAL HYDROELECTRIC PROJECTS IN NEW ENGLAND BY STATE

STATUS	ME	VT	NH	MA	
	(No.)	(No.)	(No.)	(No.)	(
Licensed Projects 1/	45	22	18	19 2/	
Constructed Projects with License Pending 1/	14	15	0	6	
Constructed Projects without Licenses	26	15	18	32	
TOTAL	85	52	36	57	
Unconstructed Projects with Licenses Pending-Preliminary Permit- or Application for permit	0	5	1	0	
	(KW)	(KW)	(KW)	(KW)	
Licensed Project	473,690	146,605	409,450	139,829 2/	
Constructed Projects with License Pending	18,497	34,460	0	18,780	1
Constructed Projects without Licenses	48,419	16,918	14,967	64,739	
TOTAL	540,606	197,983	424,417	223,348	1
Unconstructed Projects with License Pending - Preliminary Permit-or Application for Permit	0	124,500 4/	18,000	0	

1/ Includes reservoir storage projects.
2/ Does not include (2) pumped storage projects Bear Swamp (600,000 KW) and Northfield Mt. (1
3/ Does not include 7,000 kilowatts of pumped storage at Rocky River Plant.
4/ Includes 80,000 kilowatt pumped storage and conventional combination of which 47% of energ
flow.

CHAPTER VII

HYDRO-ELECTRIC FACILITIES ENVIRONMENTAL CONSIDERATIONS

The evaluation of a hydro-electric facility is a fairly forthright procedure yielding a ready assessment of the physical plant and the costs of its creation. By and large, just the reverse is true in appraising the environmental impacts of such projects. Despite that, an accurate and comprehensive appraisal of those impacts is as critical and necessary as any other factor. It must be equally considered in the decision-making process regarding a proposed hydro-electric facility.

Background

Historically, numerous river systems in New England provided spawning and nursery habitat for Atlantic salmon, shad, river herring, smelt, striped bass, and sturgeon. Because of pollution and damming, however, many previously productive reaches are no longer attainable by these anadromous species. The Federal Water Pollution Control Act Amendments of 1972 (P. L. 92-500) should result in suitable water quality for anadromous fish restoration within the next few years. However, the problem of numerous obstacles to fish passage will remain as a primary deterrent to successful restoration.

A barrier across a flowing stream induces a most significant alteration of existing conditions. For more than a century, this practice was employed in New England for a variety of reasons. We have, as a result, severely restricted habitat previously available for anadromous fishes, with a concurrent decline in these resources. Furthermore, the biological community resulting after project implementation is, indeed, different substantially from that formerly populating the area.

Were it possible to derive a creditable measure of value of the two relative habitats, we suspect, with good justification, that a dam and reservoir would not adequately replace values lost. The New England states are fortunate in having numerous natural lakes and ponds. Whether additional such areas are needed or desirable on most New England streams is questionable.

The problem of once again establishing a mechanism by which living aquatic resources can thrive in previous areas of productivity remains. If a cost-benefit ratio is applied to project costs which include facilities to allow access, many potentially satisfactory hydro-facilities would not meet the test. This, coupled with the fact that existing barriers are very expensive to alter for such purposes, suggests a problem of some magnitude to overcome. It is these factors, in addition to those outlined on the attachment, which must be addressed. And they are important ones during the entire life of the projects.

From an environmental standpoint, it might be desirable to institute a moratorium on new hydro-facilities at previously undeveloped sites, with some exceptions. However practical this view is in light of the need for additional energy sources remains to be evaluated. In any case, the secondary and tertiary impacts of energy production and availability must be factored into any proposal, a process rarely if ever accomplished.

General Considerations

The difficulty in assessing the environmental impacts of a hydro-electric facility lies in the necessity to perceive the secondary as well as the primary ones. These impacts can be categorized as both those alterations of the resources themselves and the changes in the possible uses of them. The latter category might best be addressed through a review of existing plans for the resources as they presently exist. Negative effects on planned resource use would have to be considered as a "cost" in any cost/benefit analysis.

Among such plans the respective Statewide Comprehensive Outdoor Recreation Plans (SCORP) would be a primary reference. Containing analyses of recreational supply and need, they would be an appropriate reference for determining the project's impacts, positive and negative, in terms of recreation.

On a broader scale, a wide variety of water resource studies have been completed in the region. As they offer analyses and recommendations on a wide range of land and water resource issues, these should be a primary reference.

If a given project proposal demonstrates comparability with these and other relevant plans, then there is a basis for a more detailed investigation of environmental impacts. However, if that compatability is not evident, then an evaluation of the impacts on effected plan elements/recommendations would first be necessary. If full consideration is not given to completed environmental analyses, i.e., resource plans, then the probability of environmental losses will be heightened.

Site Specific Concerns

The list of 18 projects and descriptions of each project were taken from the NENYIAC reports. It is implied, therefore, that considerations are based (at least in part) on data available when the NENYIAC report was published in 1954 -- 22 years ago. In 1972-73 the New England River Basins Commission directed a study[1/], by an inter-agency task force, of pumped-storage sites in New England. As pumped-storage is a form of hydroelectric power production, consideration should be given to possible interactions of any of the projects in this discussion with any of the NERBC's potential projects.

The Great Northern Paper Company is considering development of additional hydropower on the West Branch Penobscot between Ripegenus Gorge and Debsconeag Deadwater. Cumulative impacts of all of these projects, therefore, should be investigated to provide a more complete picture of the possible environmental impacts.

Log sluice (chutes) are included in project specifications for each of the Maine projects. Effective October 1, 1976, Maine law will prohibit further use of water for "log driving," thus log sluices will serve only to pass debris collected at the dam face. It will be more environmentally sound, however, to prohibit the practice of passing debris and require instead that it be removed from the waterway when it is collected from trash racks.

The Dickey-Lincoln School Project would have very sizeable and significant environmental impacts, from both the proposed

1/ An Environmental Reconnaissance of Alternative Pumped Storage Sites in New England. Power & Environment Committee. May 1973.

reservoir complex and the transmission corridors required to tie in with existing transmission facilities. Intensive studies are being conducted on the reservoir complex, and studies of similar scope shortly will be initiated on the transmission corridors, so further qualification is not possible at this time.

The following pertains to the Penobscot Wild and Scenic River Study area; The Arches, Basin Mills, Sourdnahunk and Winn projects would be included in the area of general discussion.

A major consideration in the development of hydro sites on the West Branch would be the impact on the existing or potential fishery resources. At any of the sites there would be major adverse impacts to the fishery resources, because the fisheries at Bid Eddy and Sourdnahunk are maintained by fish which move upstream from the lakes below. Development of all sites would almost totally eliminate the river fishery and possibly salmon altogether, because of the loss of spawning areas. We could anticipate that these flowages would become populated by warmwater species, and serve as a reservoir to invade other areas.

There are deer yards within the West Branch area. Several of these yards are located within potential hydro-power sites. Some of these, however, have not been substantiated as "permanent" areas, nor evaluated as to "carrying capacity or present utilization." These will receive further checks as part of an on-going program conducted by the Maine Department of Inland Fisheries and Game. Elimination of wintering areas could pose severe hardships on part of the deer population, because other areas are at or near carrying capacity at present. Those animals which are displaced could be forced into other wintering yards, thereby degrading the habitat quality; or subsist on marginal habitat, which may result in reduced reproduction or winter kill.

There is really not enough information available at this time to speculate on adverse impacts on bald eagles. Many physical factors about the structure, pool size, etc., would have to be known. The nest on Sourdnahunk is situated within Baxter Park and is quite some distance from the deadwater. It is doubtful that development of this site would have any adverse impact on these birds. The disturbance factor could probably be mitigated by scheduling construction time, so as not to interfere with nesting, brooding or rearing activity. If the nest were disturbed, the eagles reaction is uncertain. There is some evidence that they may move the nest some place else.

Project descriptions list acreages which would be cleared for each project. It is unlikely that transmission corridors are included in these figures. It is appropriate to note, therefore, that corridor construction, use and vegetation control could have serious impacts and should be considered in comparative evaluations of their impacts on projects. Multi-purpose planning, in fact, can be used to enhance corridor development for recreation and fish and wildlife.

The Five Islands Dam at Winn would have serious impact on Atlantic salmon restoration efforts through inundation of spawning and nursery habitat. Inclusion of a fishway would at least allow passage to and from other upstream habitat. Considerable acreages of waterfowl habitat also would be inundated by the reservoir.

It should be stressed that if the entire Penobscot inventory power plans (as described in the NENYIAC Report) were constructed, fishways probably would not be required at any of the dams; Penobscot salmon restoration simply would be unattainable. Fishways, then, would be required only if a portion of the power plan were implemented.

A Federal-State cooperative program is underway to restore Atlantic salmon and American shad to the Merrimack River Basin (New Hampshire and Massachusetts). Hydropower installations on the Merrimack and tributaries, therefore, would have to be responsive to this ongoing effort. This would involve consideration of fish-passage facilities, instantaneous minimum flows, fisherman access and the impact of inundating spawning and nursery habitat. The Livermore Falls, Tilton, Riverhill and Moores Falls projects would be included in this area of general discussion. The Sewalls Falls power plant has been retired from service since the NENYIAC Report was issued; consideration should be given to the possible effects of discharging water from Riverhill to the Sewalls Falls pool via the power canal, bypassing the reach from Riverhill to the confluence of the Contoocook River with the Merrimack River.

A Federal-State cooperative effort also is underway to restore salmon and shad to the Connecticut River Basin. The proposed Enfield project would include a "fishway and fish elevator," according to NENYIAC project description. We submit that a fishway, properly designed, would eliminate need for a fish elevator. Consideration should be given to the possible effects of backing reservoir headwaters to the Holyoke Dam area; project design should insure that migrant fishes will not be stressed while negotiating the dams. The Deerfield River has salmon spawning habitat; the Meadow Dam should provide fishway facilities and instantaneous minimum flows for migrant fishes.

Other Considerations

The principal determinant of the project's impacts would be whatever alterations the project produces in the water's form and character.

Form changes would most directly relate to land resource impacts. Aside from the loss of acreage, impacts would include disruption or alteration in patterns of use by both man and wildlife. All of these would have to be examined in terms of both type and magnitude of impact. Unfortunately, many of the possible impacts are not assessable in economic terms. Despite this, the final balance of values leading to a project decision should incorporate such considerations.

In terms of water quality impacts, the following factors are those needing closest attention.

1. Thermal stratification
2. Settling basin effect
3. Eutrophication
4. Light Penetration and turbidity removal
5. Oxygen production and demand
6. Carbonate equilibrium
7. Iron and manganese
8. Artificial destratification of impoundments

9. Thermal pollution

10. Downstream quality

11. Groundwater effects

12. Watershed development

As has been stated at times throughout the report it has been attempted to present factual data upon which decision makers might act. The following Chapter prepared by the New England River Basins Commission (and reviewed by the Corps of Engineers, Federal Energy Administration, and the New England Regional Commission) represents one solution.

CHAPTER VIII - NERBC PROPOSAL

PROGRAM TO DETERMINE FEASIBILITY AND IMPLICATIONS OF EXPANDING HYDROELECTRIC POWER GENERATION IN NEW ENGLAND

NERBC Staff Paper by Thomas E. Klock, 3/30/76*

SUMMARY

(1) Findings from an initial assessment of the feasibility for hydropower expansion in New England are favorable enough to suggest that follow-up investigations are definitely in order.

(2) Three major opportunities for hydropower expansion should be considered: (a) large new sites, (b) new small sites, and (c) existing/abandoned very small sites.

(3) A program to follow-up the FRC findings should consist of three separate phases.

- (a) PHASE I - General assessment of the role of hydropower (Level A - type study)
- (b) PHASE II - Selected site reconnaissance (Level B-type or special study) from a water resources perspective.
- (c) PHASE III - Detailed project engineering and design (Level C study) for recommended projects.

(4) The importance of PHASE I to the region cannot be overstated. There is a major need to put a true perspective on the technical and economic feasibility of hydropower, as well as the environmental trade-offs that should be considered.

(5) The entire program (3 phases) should be managed to provide a water resources point-of-view. NERBC is the appropriate vehicle for this purpose as authorized by Congress, and should consider establishing a water resource-based inter-agency study team to conduct the program, probably through the leadership of the Corps of Engineers

*This version includes comments by John Leslie (Corps) and Frank Gregg (NERBC). Also contains information furnished by William Albert (Vt. AEC).

(6) The Cost for PHASES I and II is estimated at $600,000 - $800,000, not including preparation of an EIS. A number of options are available to obtain these funds, including application by NERBC for a Special Study through the Water Resources Council.

(7) The time schedule would be one year for PHASE I, two years for PHASE II, and two or three years for PHASE III. The earliest construction start-up for a large hydro facility would probably be FY 1982 if the program were to start by the next fiscal year. Small facilities could be much sooner.

REVIEW OF HYDROPOWER ISSUES

The sudden steep rise in the cost of electricity suggests that a fresh look at the place of hydroelectric power generation in New England is in order. The primary cause of this steep rise is the sky rocketing cost of residual oil (up by over 600 percent in the last several years) upon which New England is primarily dependent for producing electricity. Of almost equal significance is the increase in construction cost of thermal generation plants, particularly those which are nuclear powered. With New England placing increasing emphasis on use of nuclear power, the disproportionate cost factor for generating electricity is placing the region at an even greater economic disadvantage in comparison to other U.S. regions.

Discussions on this topic have dominated recent intergovernmental forums which have attempted to discern a possible energy strategy which would reduce New England's disadvantage. One of the possibilities discussed is the undeveloped hydropower potential for increasing generation capacity. A number of benefits have been singled out if hydropower expansion proved feasible, both large and small facilities.

-- A significant contribution could be made to New England's overall generation capability.

-- A more diversified power generation capability would be provided, this reducing New England's vulnerability to possibilities shortages effecting electrical generation (both fossil and nuclear).

-- An indigenous source of power would be utilized.

-- Power abudance could be created at rural or small town locations, thereby enhancing their attractiveness for industry.

-- Installations already in existence, but abandoned or not being operated, could be restored within a reasonable cost level.

-- A contribution could be made to reducing overall demand for imported oil.

On the other hand, these alleged benefits are being subjected to considerable questioning, which in turn has subdued greatly any private industry or utility interest in pursuing such a power option. In effect, little effort to reconsider hydropower generation can be found outside of governmental institutions at this time. The questions being raised include:

-- Can enough additional hydroelectric power be generated from many small and dispersed sites to make a power contribution worth pursuing?

-- How difficult is the integration into the region system of many small sources which have questionable reliability?

-- Is there adequate year-round flow of water in New England's rivers to maintain a reasonable level of power output?

-- How will expanded hydropower generation, either large or small, affect other riverine uses such as salmonid fish restoration and water quality improvement?

Thus we have industry and some government agencies with many years of experience working with hydropower in New England telling us to be extremely cautious about pursuing hydropower options, while at the same time other government officials are thinking that a new hard look at hydropower possibilities should be considered in view of the energy crunch.

REVIEW OF ISSUE-RELATED ACTIVITIES

FRC Energy Program - Under its fiscal year 1976 work program, the New England Federal Regional Council has organized a task force of federal and state officials to examine government involvement in the energy situation. Particular emphasis is being placed on identifying where federal efforts could be strengthened to avoid unnecessary conflicts, and also to facilitate "comparison of lead time" for governmental response on energy related applications. Within this framework, a subcommittee of the task force, chaired by the New England Division of the Corps of Engineers, has been evaluating hydropower possibilities by listing potential sites, inventorying regulatory requirements, discussing environmental considerations, assembling private utility viewpoints, and investigating costs.

Special attention has been directed by the task force toward updating the cost information supplied in the NENYIAC (New England - New York Inter-Agency Committee) Report. The report compiled information about 1200 dam sites (both existing and potential) considered as having possibilities of development for power and storage purposes. However, the NENYIAC investigation was limited to those sites which had either (1) a potential power capacity of at least 1000 kilowatts, or (2) a potential storage capacity of 500 acre-feet. Of these, 59 were selected for further consideration because of a favorable B/C ratio. The updating by the Corps of cost information for these 59 sites suggests that 18 are still viable for consideration on the basis of either marginal or favorable B/C ratios. Of these sites, 16 would be capable of producing about 975 mw for peaking power purposes, not including the added potential of another 1830 mw from the Dickey-Lincoln and Passamaquoddy projects.

FEA Activity - In order to respond to inquiries by the Town of Wareham, Mass., on restoring a small hydropower operation in that town, the regional office of the Federal Energy Administration coordinated a review of the potential for a cost-effective project. The results were that this project could be conducted as a demonstration for evaluating similar potential projects in other parts of New England.

MITRE Corporation has prepared some estimates showing that the cost of generation with fossil or nuclear plants has changed to such an extent that the region-wide economic picture for hydropower may now be favorable, especially in meeting the demand for high-cost peaking power. Their conclusions were that New England has significant under-developed potential in hydropower, amounting to at least 4000 mw, or 18% of today's total New England generating capacity. There exists over 3000 small existing dams, no longer used for power purposes, which could be considered for restoration or addition of a hydropower function.

The work plan suggested as being appropriate for evaluating New England hydropower potential should consist of the following key elements:

(1) Identify regional hydropower potential

(2) Evaluate institutional constraints and incentives

(3) Review planning and implementation issues, such as leadtime and equipment costs.

(4) Study operational and technical issues, such as controlling large number of sites and integrating them into the system

(5) Examine regional generation requirements to determine effect hydropower could have (regionally and locally)

(6) Assess environmental impacts

NERCOM - Under its "Revision To NERCOM's Regional Development Plan", a program activity has been suggested to identify the feasibility and potential capacity for generating electricity at existing small hydro sites. The program would also be handled in two stages, with the first aimed at selecting appropriate rehabilitation sites and preparing engineering designs, and the second to provide a labor force to perform necessary reconstruction at selected sites for demonstration purposes. The total funding suggested is $500,000 and $2,500,000 for each stage, respectively.

NECWCD - A draft proposal entitled "The Impact of Water Availability on Electric Energy Production in New England" has been prepared for consideration by the New England Council of Water Center Directors. The project is to provde "an analysis of technological, economic, and institutional factors governing the dynamic relationship between water use and electric power generating facilities and the resulting effects on the patterns and rate of economic development in New England." The final product expected would be the development of one or more decision models for relating water resource management with electric energy generating decisions. It is anticipated that such models would provide for improved recognition of the need to link water availability with decisions concerning electric energy generation. The project would look at various generation modes, including hydro.

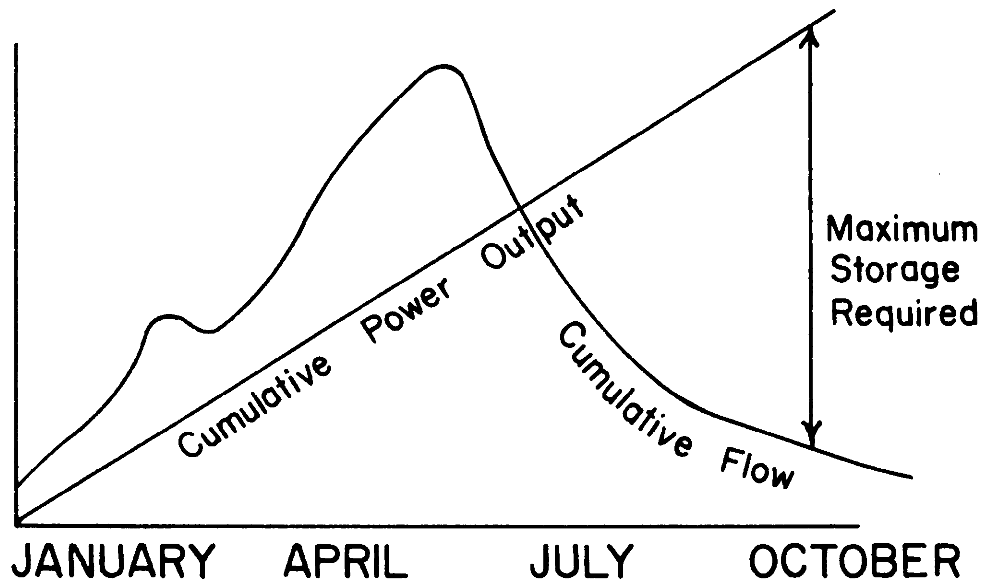
Other Interest

The State of Vermont, by letter from its Department of Water Resources, has requested NERBC to act as a regional sponsor for a program to examine the potential for hydropower expansion in the state. The Department notes that a fast developing trend in the state is the focus of attention on developing new or redeveloping former hydropower sites -- those which are not large enough for inclusion in major water resources planning efforts, but which collectively can satisfy Vermont's demands. Local officials and citizenry have suddenly become captivated with the notion that building small hydropower facilities may be the way to reduce the disproportionate cost of electricity in that state. Scores of towns are actively forming citizens committees to look into the feasibility of public power, especially from hydro facilities. The activity is so pitched that already conflicts are emerging among adjoining towns over the management of common water resources, and competition has developed between public and private groups over use of a potential hydro site.

Rhode Island has also displayed active interest in pursuing the hydropower potential. State officials have sponsored a workshop to discuss possibilities for taking advantage of the many existing mill sites in the state. Interest is also present in New Hampshire where the state legislature has displayed interest in thoroughly examining the hydropower potential in the state.

WATER MANAGEMENT PERSPECTIVE

The lack of understanding being demonstrated thus far on the principals governing hydropower generation is a prime example of the need for a water management perspective. Estimates for generation potential are currently being prepared on the basis of annual average flow in the stream, without due consideration being given to how the flow varies over the year. The following chart displays in simplified fashion, the problem that emerges when flow is compared with cumulative demand. The gap between the two curves illustrates the storage capacity needed to maintain an output level during low flow periods.



With the possibility existing of creating interrupted downstream flows and aesthetically unpleasing storage reservoirs, the use of water for hydropower purposes in many instances is in direct competition with other uses such as salmonid fish restoration, water quality improvement, stream bank stabilization, and some forms of water-based recreation. A great deal of controversy has been associated with efforts to expand hydropower, both in this region as well as in other parts of the country. Thus, the public interest would best be served if controversies such as these could be minimized by conducting studies to investigate the feasibility and implications of hydropower expansion early in the planning process. To be most effective, these studies should be multipurpose in scope, and should be conducted within the framework of river basin management principles.

Under P. L. 89-80, NERBC is charged with the responsibility to serve as the principal agency for coordinating federal, state, interstate, local and non-governmental plans for the development of water and related land resources. To carry out this responsibility, NERBC has the authority to perform special studies on water-related issues, and it is within this context that NERBC could provide the water management perspective on the issue of expanding hydropower.

HYDROPOWER OPPORTUNITIES TO EXAMINE

From the work of the FRC Task Force, three areas of opportunity for hydropower expansion can be identified - (1) large hydro, (2) new small hydro, and (3) very small hydro. The following explores for each category the approaches that would be appropriate for determining project feasibility and implications from a multipurpose viewpoint.

Large Hydro - Experience has shown that large hydro facilities are particularly prone to evoke controversy, due to conflicting utilization of affected water resources. To address this latent potential for controversy, sufficient information should be provided early in the planning process about economic, social, and environmental considerations. The responsibility to provide this information rests with governmental agencies who would be closely associated with the decision-making process concerning large sites.

Three related program steps need be conducted. The first would provide a general assessment of the role of hydropower in an energy strategy for New England. The second would provide a reconnaissance of specific sites which showed promise for further investigation. And the third step would be the development of detailed engineering and design work for those sites which the reconnaissance effort clearly showed offered public benefits which outweighed impacts and costs.

New Small Hydro - This opportunity relates to the possibility of municipalities and some utilities constructing new relatively small facilities. Already three new facilities are being applied for - one on the Black River in Vermont for municipal hydropower, another on the Lamoille River in Vermont for a public utility, and a third on the Winooski River by both a municipality and a public utility in competition with each other. Another town has had a feasibility report completed on a \$60-\$70 million facility on the Mississippi River involving pumped storage. Two more towns are undertaking feasibility studies to investigate project potential on the Winooski North Branch and the upper Black River.

Since each new proposal would be subject to the licensing process of the Federal Power Commission, the process does provide a vehicle for evaluation of economic, social, and environmental impacts. An important service could be provided if the process were monitored to identify criteria which could be utilized in considering other potential projects in the region.

Also, the potential for new small hydro facilities needs to be examined from a regional system point-of-view, and could be included under the first level study for large hydro facilities.

Very Small Hydro - This opportunity for expanding hydropower through very small dams rests chiefly with individual communities. The total amount of power produced from these facilities may not be important in terms of the integrated regional system, as each facility may only be capable of generating 200-300 kilowatts. Nonetheless, important savings could be accrued on the basis of the much more expensive peaking power needs. A three stage investigative program similar to the one suggested for large hydropower facilities needs to be conducted for each very small hydro site. This would be a mammouth undertaking on a regional level, inasmuch as at least 2000 sites may be suitable for development or restoration under current technological and economic conditions. Instead, a program should be undertaken to examine a small number of sites displaying, in all, a wide range of conditions and circumstances that could be encountered. From this could be assembled a guide which would set forth criteria and principles to follow for evaluating other sites from an economic point-of-view, as well as social and environmental implications. The next step would be to prepare engineering designs for selected sites. An additional step could also be included - that of undertaking actual restoration at a number of selected sites to provide demonstration projects.

PROGRAM ORGANIZATION

There are three phases of investigation appropriate for conducting a program on the potential for expanding hydropower in New England. Proceeding with each phase of investigation would be contingent upon the results of the previous phase of study activity. The following provides some initial ideas on what work would be performed for each phase, approximate cost, and possible agency involvement.

PHASE I - ASSESSEMENT OF ROLE OF HYDROPOWER

This level of activity would be comparable to the work performed under a Level A-type study on water resources. The work would include a comprehensive assessment of all types of hydro facilities (large to very small) from a regional perspective to determine whether additional facilities have a place in the future New England energy scene, and if so, the extent of contribution that could be expected. The assessment should identify:

(1) The extent of power that could be supplied, and the reliability factor.

(2) The type of power to be furnished (base load or peaking).

(3) Cost comparisons with other modes of generation.

(4) Reduction of dependence upon outside fuel sources that can be expected.

The approach taken should provide for close coordination with private utilities, and in particular with NEPOOL, inasmuch as their latest 10-year projections emphasize reliance on generation technologies other than hydro.

PHASE II- RECONNAISSANCE OF SELECTED SITES

This level of program activity would be comparable to a Level B-type or special study using the accepted comprehensive water resource planning approach. With preliminary findings about the role of hydropower from early work under PHASE I, a quick fix could be obtained on which potential sites should be examined more closely under PHASE II. The following details activities for each hydropower category being considered.

Large Hydro - A specific site analysis would be conducted utilizing WRC principles and standards for comprehensive water resource planning. To perform the work, a study team would be organized, and would consist of representatives from the Corps of Engineers, U. S. Fish and Wildlife, Environmental Protection Agency, Federal Power Commission, and Department of Agriculture. The task would require 12 months to perform, at a cost of \$200,000 - \$250,000 to support the study team. This would provide for at least 6 man-years, plus consulting, travel, report printing and administrative expenses. Probably \$75,000 - \$100,000 of this amount would be assigned to the lead agency (most likely the Corps) to cover study management costs. An additional one-year effort would be needed to prepare the EIS, at a minimum cost of \$250,000 per site.

New Small Hydro - The study team could also provide a monitoring role of the FPC licensing process to select criteria for general application. From this activity, a guide could be prepared, which would require about 2 man-years of effort plus accompanying support services by state representatives. The cost of this effort (including time and travel support) would probably be in the range of \$50,000 - \$75,000.

Very Small Hydro - The task to be performed for this category would be similar to the above task, but would be correlated with the work of the proposed NERCOM effort. Involved would be a monitoring of the evaluation of very small hydro sites to assemble criteria for general application from a comprehensive water resources perspective. A similar amount of study team effort would be required, with a cost in the range of \$50,000 - \$75,000.

PHASE III - PROJECT ENGINEERING AND DESIGN

The extent of activity under this phase would depend upon the findings of the preceding phase. For large hydro facilities, information would be available for Congressional authorization of funds to proceed on Level C - type studies for specific projects. The Corps of Engineers would be the most likely agency to perform this activity. Each project authorized would be dealt with separately, and current estimates are that each project would require 30-40 man-years for foundation exploration, hydrology, final design, and drawings, at a total cost in the area of $1 million per project.

Federal and state agency involvement in this phase for new small hydro would be limited to appropriate activities under the licensing process. For very small hydro facilities, as mentioned before NERCOM is contemplating providing considerable assistance to provide New England with project demonstrations.

PROGRAM TIMING

If the 3 phase program is to be undertaken, it is important that the timing of the phases be carefully integrated with budget appropriation periods so that funding difficulties and subsequent delays are not encountered. Immediate inquiry for potential PHASE I funding is needed if an early start-up is envisioned. For funding to be channeled through WRC, submittal of a plan-of-study would have to be accomplished by June of this year in order to obtain consideration for FY 78 funding. Given a FY 78 start-up, PHASE I and II could be completed by FY 81, and construction could conceivably begin on selected projects by FY 83. This schedule could be advanced one year if funds to start PHASE I would be available by FY 77.

RELATIONSHIP TO FRC DEVELOPMENT TASK FORCE

In effect, this three phase work program would replace work currently being addressed by the FRC Sub-Committee on Hydropower. Continuity with the FRC program would be provided by continued participation on the proposed interagency study team of individual agencies currently serving on the sub-committee. Continuity could also be provided by the Corps assuming the lead agency role for the Phase II work.

APPENDIX

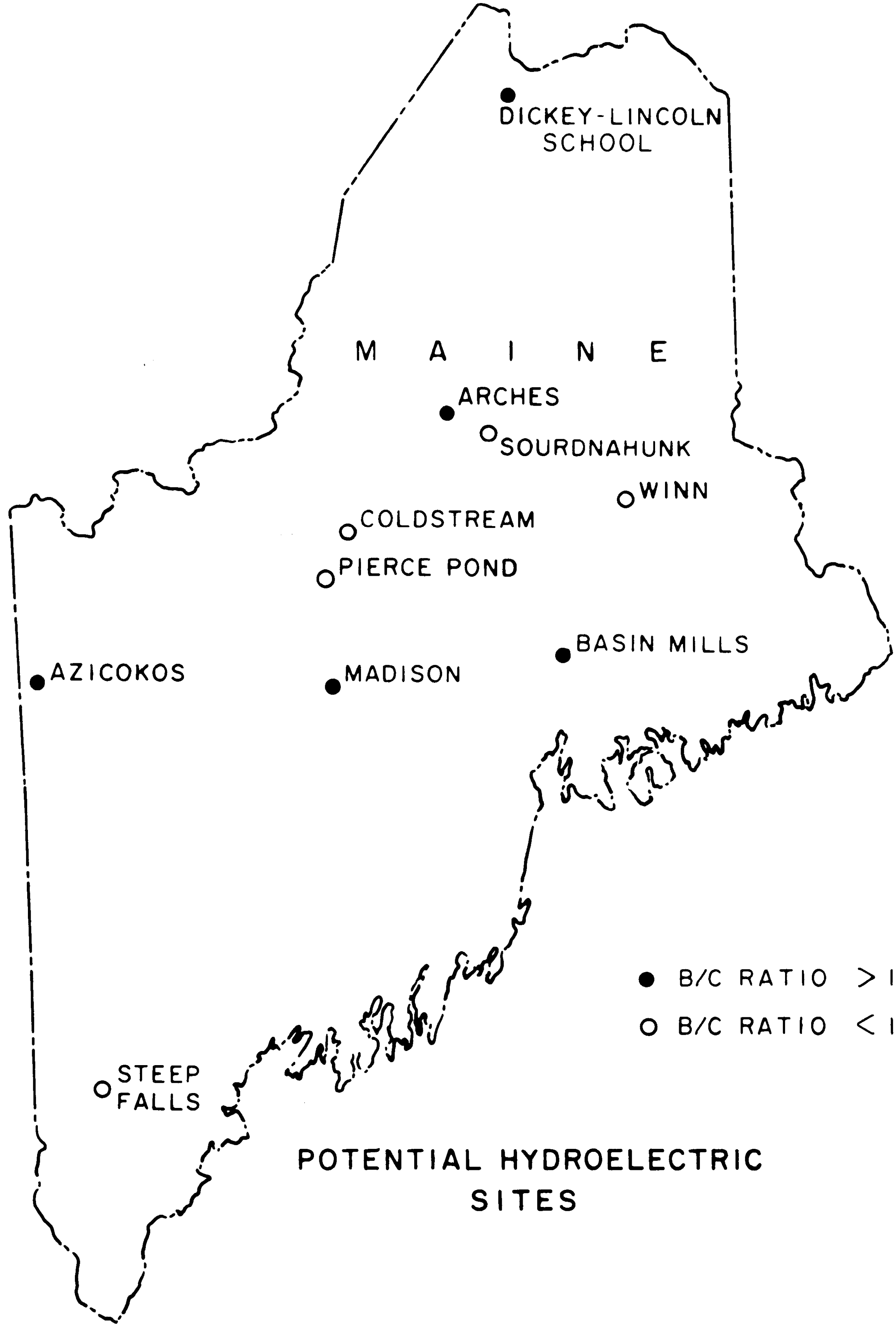
DESCRIPTION

OF

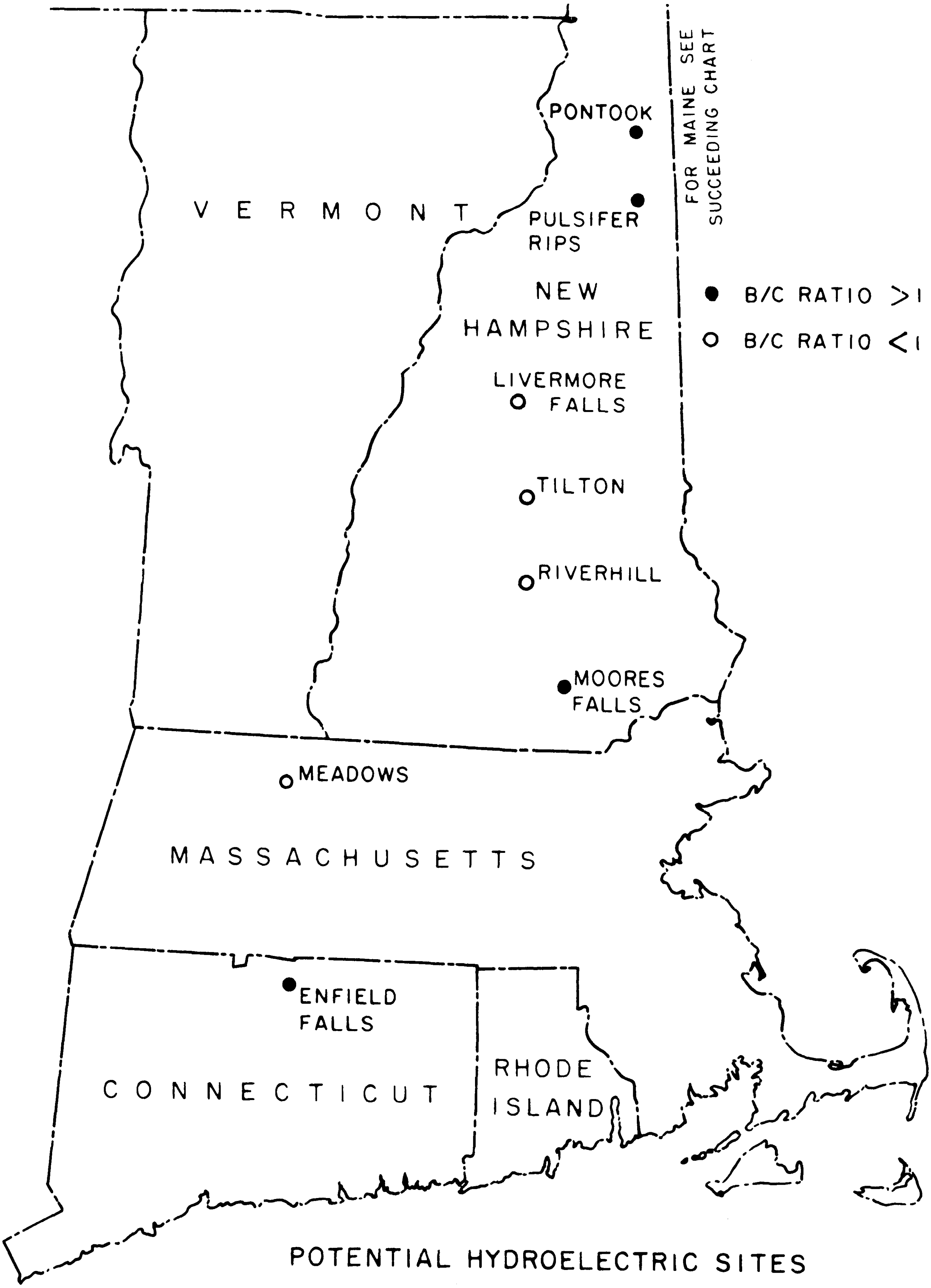
POTENTIAL HYDROELECTRIC SITES

IN

NEW ENGLAND



POTENTIAL HYDROELECTRIC
SITES



POTENTIAL HYDROELECTRIC SITES

THE ARCHES

This site, with a drainage area of 1,415 square miles, is on the West Branch Penobscot River about two miles below Ripogenus Dam and 50.1 miles above its mouth at Medway. The dam would be of concrete and would have an overall length of 460 feet including an intake section 80 feet long for a penstock, a gate-controlled spillway section 200 feet long, a log chute, and a fishway. It would have a maximum height of 52 feet. The project would utilize a gross head of 90 feet between a headwater elevation of 760 feet, m. s. l., at the dam, and a tailwater elevation of 670 feet, m. s. l., at the powerhouse located about 5,000 feet downstream. Generating facilities for 50,000 kilowatts, in one unit which would produce an average of 94,250,000 kilowatt-hours annually at a capacity factor of 21 percent, would be installed in the powerhouse. The project would require the acquisition of clearing of 35 acres of land. The estimated total first cost of the project is $34,207,000.

SOURDNAHUNK

This site is on the West Branch Penobscot River about 43.5 miles above its mouth and 8.5 miles below Ripogenus Dam. It has a drainage area of 1,435 square miles. The project would provide for a concrete dam with an overall length of 1600 feet including intake structure, a 500-foot free-overflow spillway, a 150-foot gate-controlled spillway, a log chute, and a fishway. It would utilize a gross head of 95 feet between a headwater elevation of 670 feet, m.s.l., and a tailwater elevation of 575 feet, m.s.l. To obtain this tailwater elevation, a tailrace excavation for a distance of approximately 6,500 feet would be required. Generating facilities for 50,000 kilowatts in one unit would be installed in a powerhouse in the river channel directly below the dam. The plant would produce an average of 109,450,000 kilowatt-hours annually at a capacity factor of 23 percent. The acquisition of several sets of buildings and 1,020 acres of land, and the clearing of 800 acres would be required. Approximately 5.3 miles of gravel road and transmission line would be relocated. The estimated total first cost of the project is $54,588,000.

WINN (FIVE ISLANDS)

This site, with a drainage area of approximately 4,870 square miles, is on the Penobscot River near the village of Winn, about two miles below the mouth of the Mattawamkeag River. It would get the full benefit of all storage developed on the Mattawamkeag and East Branch Penobscot Rivers. A rock-fill and concrete dam approximately 1,200 feet long would be constructed to develop a gross head of 23 feet between a headwater elevation of 199 feet, m.s.l., and a tailwater elevation of 176 feet, m.s.l.. A tailrace excavation approximately 500 feet in length would be required to obtain this tailwater elevation. The concrete section, which would occupy the existing river channel, would contain a gate-controlled spillway, a fishway, a log chute, an intake structure and powerhouse. The project would require the acquisition and clearing of 1,500 acres of land, and the raising or relocation of about 1.5 miles of railroad, two miles of highway, and two miles of power and telephone lines. Generating facilities for 50,000 kilowatts, in one unit, which would produce an average of 89,170,000 kilowatt-hours annually at a capacity factor of 20 percent would be installed in the powerhouse. The estimated total first cost of the project is $54,749,000.

BASIN MILLS

This site, located on the Penobscot River at Orono, would be developed by the construction of a concrete dam with earth abutments approximately 1,550 feet long and 45 feet high, containing a 400-foot uncontrolled spillway, a gate-controlled spillway, a log chute, fishway, and an intake structure and powerhouse. It would utilize a gross head of 27 feet between a headwater elevation of 62 feet, m. s. l., and a tailwater elevation of 35 feet, m. s. l. Although located in a well-developed industrial area, it would have no adverse effect upon existing industries, nor would it affect any extensive housing areas. The reservoir would drown out the present Orono plant which is an old plant and may become inoperative in the future. Generating facilities for 50,000 kilowatt, in two units, which would produce an average of 93,150,000 kilowatt-hours annually at a capacity factor of 21 percent, would be installed in the powerhouse. The project would necessitate the acquisition of 400 acres of land, several sets of buildings, and the clearing of 300 acres. The estimated total first cost of the project is $46,993,000.

COLD STREAM

This site, with a drainage area of 1,416 square miles, is on the Kennebec River about 125 miles above its mouth. It is about 3.5 miles above the village of The Forks and 0.2 miles above the confluence of Cold Stream and the Kennebec River. The dam at this location, from its right to its left abutment, would consist of approximately 1,300 feet of earth fill, a 330-foot concrete non-overflow section including penstock intake and fishway, a 200-foot gate-controlled spillway, and a 300-foot concrete non-overflow section containing a log sluice, making a total length of 2,130 feet. The earth section would be located in the existing river channel; the concrete section in a low saddle in the left abutments. The project would develop a gross head of 195 feet between headwater and tailwater elevations of 805 and 610 feet respectively. The powerhouse, located approximately 500 feet downsteam of the dam, would contain generating facilities for 120,000 kilowatts in two units which would generate an average output of 259,350,000 kilowatt-hours annually at a capacity factor of 25 percent. There would be no provision for storage other than daily pondage requirements. The total estimated first cost of the project is $125,597,000.

PIERCE POND

This project provides for power generation and the diversion of flow from the Flagstaff Reservoir and the Grand Falls Reservoir project on the Dead River, by means of a pumping station and canal, to Pierce Pond on Pierce Pond Stream. Pierce Pond would be raised 33 feet to form a pool at an elevation of 1, 175 feet. The dam, 3, 350 feet long, would be of earth with a 440-foot central concrete section containing provisions for an intake section, a log sluice, and a 50-foot free overflow spillway section. Two 17-foot diameter penstocks, each 14, 750 feet long, would extend from the intake to surge tanks. Two penstocks, 2, 760 feet long, would connect the surge tanks to the powerhouse on the right bank of the Kennebec River at about mile 132, just below the upper limits of the pool of Wyman Dam. A gross head of 690 feet would be developed between a headwater elevation of 1, 175 feet and a tailwater elevation of 485 feet. The powerhouse would contain two 110, 000 kilowatt generating units, a total of 220, 000 kilowatts capable of producing an average of 459, 000, 000 kilowatt-hours annually at a capacity factor of 24 percent. In addition to the power facilities, a single pumping installation near the upper end of the Grand Falls reservoir, just below the existing Long Falls Dam, together with pressure lines and a canal to Pierce Pond, would be required to complete the project. Off-peak pumping would require 76,200,000 kilowatt-hours annually. Only pondage of 10,000 acre-feet would be utilized. The total estimated first cost of the project, including the pumping plant and canal system, and the Grand Falls Reservoir project would be $217,154,000.

GRAND FALLS RESERVOIR

The dam site is on the Dead River about 14 miles above its mouth at the village of The Forks and about 0.5 mile below the junction of Spencer Stream and the Dead River. The gross drainage area at the site is 769 square miles of which 520 square miles are controlled by the existing Flagstaff Reservoir. The project would include a dam constructed largely of earth. A spillway channel approximately 300 feet wide, with control afforded by six, 41-foot by 20-foot taintor gates, would be located on the right bank. A 275-foot concrete non-overflow section, starting 180 feet beyond the spillway section, would contain provisions for a log chute and fishway. The remainder of the structure would consist of 2,000 feet of earth fill with a maximum height of 130 feet. A conduit, founded on ledge, would be located under the earth section in the present river channel. An earth dike, 3,900 feet long would be required on the right bank; one 3,000 feet long on the left bank. With a spillway elevation of 1,095 feet, the project would provide 226,900 acre-feet of usable storage capacity to be utilized in conjunction with the Pierce Pond power project. These two projects are linked together and comprise the Pierce Pond Diversion. The total estimated first cost of the project is $11,902,000.

MADISON (HIGH DAM)

The dam site, with a drainage area of 3,230 square miles, is on the Kennebec River about 75 miles above its mouth and about one and one-half miles below the Town of Madison. The site would be developed by the construction of a concrete dam, 745 feet long, consisting of a 105-foot non-overflow section at the left abutment, a powerhouse section 115 feet long, a fishway and log sluice section 20 feet long, a 295-foot spillway section containing six 40-foot by 20-foot taintor gates, and 210 feet of earth embankment at the right abutment. A gross head of 64 feet would be developed between a headwater elevation of 222 feet and a tailwater elevation of 158 feet. The headwater elevation of this project would be the same as that of the present Kennebec Pulp and Paper Company dam located about one mile upstream which would be inundated together with the company's pulp mill and associated power plant. Construction of this high dam project could only be accomplished when and if the existing power plant and pulp mill were abandoned. The project would include a powerhouse with an installed generating capacity of 80,000 kilowatts which would produce an average of 146,800,000 kilowatt-hours annually at a capacity factor of 21 percent. The total estimated first cost of the project is $48,871,000.

Consideration was also given to the possibility of (2) a low dam at the Madison site which would not inundate the existing pulp mill and power plant of the Kennebec Pulp and Paper Company, and (b) the development of the Madison site in two stages.

a. A low dam at the Madison site in lieu of the high dam Madison power project contained in the inventory power plan would develop, a gross head of 23 feet between the tailwater elevations of 181 and 158 feet, respectively, instead of the 64 feet of head below an elevation of 222 feet, that would be developed by the high dam. The pool of the low dam would extend upstream about one mile to the tailwater of the Kennebec Pulp and Paper Company dam. A concrete dam, 620 feet long, would be required with a layout somewhat similar to that of the high dam. Considerable rock excavation would be necessary to provide for the gate section.

b. A two-stage development at the Madison site was considered. The construction of a low dam would incorporate features to permit the ultimate raising of its pool level from an elevation of the high dam in the inventory power plan.

AZISCOHOS

This project provides for the construction of a concrete intake structure, 50 feet high and 20 feet long, on the left side of the log sluice in the buttress section of the existing dam at the outlet of Aziscohos Lake on the Magalloway River. The drainage area at the dam is approximately 214 square miles. A penstock, 5,800 feet long, would extend from the intake to a surge tank 68 feet high and 30 feet in diameter. A penstock, 1,600 feet long, would connect the surge tank to the powerhouse located downstream on the Magalloway River. A log sluice would be constructed from the dam to the vicinity of the powerhouse to permit the passage of pulpwood drives. The project would develop a gross head of 245 feet between the existing headwater elevation of 1,520 feet, m.s.l., and a tailwater elevation of 1,275 feet. Generating facilities for 25,000 kilowatts, in one unit, would be installed in the powerhouse. The plant would produce 49,080,000 kilowatt-hours annually at a capacity factor of 22 percent. With the installation of power and a drawdown of 26 feet, usable storage would equal 159,300 acre-feet, or about 73 percent of the 218,300 acre-feet presently available in the lake. The estimated total first cost of the project is $11,875,000. This figure includes no part of the cost of the existing dam and reservoir that was completed in 1912.

<u>STEEP FALLS</u>

This site, with a drainage area of 1,340 square miles, is on the Saco River 33.5 miles above its mouth and 0.25 miles below the village of Steep Falls, Maine. The project would provide for a concrete and earth dam with an overall length of approximately 950 feet. The concrete section, crossing the existing river channel, would contain a powerhouse, a fishway, a log sluice, a 300-foot gate-controlled spillway and a 40-foot uncontrolled spillway section. A gross head of 38 feet would be developed between a headwater elevation of 268 feet, mean sea level, and a tailwater elevation of 230 feet. The powerhouse would contain generating facilities for 30,000 kilowatts in one unit, capable of producing 47,690,000 kilowatt-hours annually at a capacity factor of 18 percent. The total first cost for the complete development is estimated at $32,652,000. The acquisition of land and necessary reloactions would constitute only a small part of the cost.

PONTOOK

This site is on the Androscoggin River about 18 miles below the Errol Dam and immediately downstream of an existing crib dam that is used for pondage and log driving. It has a drainage area of 1,214 square miles. The dam, approximately 700 feet long, would be of earth with a center section of concrete, about 300 feet long, containing a 200-foot gate-controlled spillway. The powerhouse would be located about two miles farther downsteam and would be connected to the pool of the dam by a canal and penstocks through a saddle on the left bank. The canal, 2,500 feet long, would extend from the pool to an intake structure. Two penstocks, each 2,300 feet long, would lead from the intake structure to the powerhouse. A log sluice would parallel the penstock from the lower end of the canal. Approximately 80 feet of gross head would be developed between a headwater elevation of 1,175 feet, and a tailwater elevation at the powerhouse of 1,095 feet. Two 25,000 kilowatt generating units - a total capacity of 50,000 kilowatts - would be installed in the powerhouse. The plant would produce 88,410,000 kilowatt-hours annually at a capacity factor of 20 percent. The project would have adequate pondage to permit reregulation of peaked flows from upstream developments so that

they would coincide with the 24-hour operation of downsteam paper mills at Berlin. The project would necessitate the acquisition of approximately 2,100 acres of land, practically all of which would require clearing, and several sets of buildings. Six and one-half miles of highways and utility lines would have to be relocated.
The total first cost for the complete installation is estimated at $40,560,000.

PULSIFER RIPS

This site, with a drainage area of 1,363 square miles, is located about 2.5 miles above Gorham. It would be developed by the construction of a concrete and earth dam approximately 900 feet long. The concrete section, in the existing river channel and on the right abutment, would contain provisions for a penstock intake, a fishway, a log sluice, and 150 feet of gate-controlled spillway. A penstock 4,700 feet long would be required in order to utilize the total gross head of 40 feet available between a headwater elevation of 854 feet at the dam and a tailwater elevation of 814 feet at the powerhouse. This is the presently undeveloped head between the tailwater of the Brown Company's Cascade Mill plant and the headwater of their Gorham Dam. The powerhouse would contain two generating units of 12,500 kilowatts capacity each which would produce 42,640,000 kilowatt-hours annually at a capacity factor of 20 percent. Pondage at the site is extremely limited and it would be necessary to operate the plant on a 24-hour basis at an annual capacity factor of approximately 85 percent in order to utilize the water discharged from existing paper mill hydro plants upstream. The total first cost of the project is estimated at $24,799,000.

LIVERMORE FALLS

This site, with a drainage area of 408 square miles, is located on the Pemigewasset River in the Town of Campton, two miles north of Plymouth, New Hampshire. The reservoir, at full power pool, would be 12 miles long, have a maximum width of two miles, and cover an area of 5,500 acres. The dam would be approximately 2,800 feet long and consist of a concrete section across the present river channel and 1,900 feet of rolled-earth fill on the left bank. The concrete section would contain a 380-foot non-overflow section, a 220-foot overflow section topped by 12-foot stanchions, a 208-foot overflow section controlled by four 42-foot tainter gates, a power intake section, and a skimmer gate. The dam would have a maximum height of about 180 feet. Storage of 135,000 acre-feet, between an elevation of 611 feet, mean sea level, and a spillway crest elevation of 633 feet would be reserved for flood control; and 170,000 acre-feet, between elevations of 611 and 569 feet would be utilized for power purposes. A gross head of 149 feet, between a full power pool elevation of 611 feet, and a tailwater elevation of 462 feet would be developed at the dam. Generating facilities for 35,000 kilowatts in one unit, would be installed in a powerhouse located immediately below the dam. The annual output of the plant would average

69,800,000 kilowatt-hours at a capacity factor of 23 percent. Construction would necessitate the acquisition of approximately 8,600 acres of land including all or portions of several villages; and the relocation of industrial developments in Campton, sections of the railroad and highway which closely parallel the river in the reservoir area. The total estimated first cost of the portion of the project allocated to power is $44,295,000.

TILTON

This site, with a drainage area of 482 square miles, is located on the Winnipesaukee River, in the Town of Franklin, New Hampshire. The dam would consist of a concrete ogee section, 195 feet long, and a penstock intake on the right bank. A penstock, 3,000 feet long, would extend downstream to a differential surge tank which would in turn be connected to the powerhouse by a 700-foot long penstock. The project would develop a gross head of 92 feet between a headwater elevation of 408 feet, mean sea level, and a tailwater elevation of 316 feet. The power plant would contain a 20,000 kilowatt generator and produce an average annual output of 29,600,000 kilowatt-hours at a capacity factor of 17 percent. Due to channel constructions and pondage limitations, the operation of this plant would have to be coordinated with existing upstream and downstream plants. The project would involve no important relocations and require the acquisition of only about 100 acres of land. The total estimated first cost of the project, exclusive of existing water rights, is $15,969,000.

RIVERHILL

This site, with a drainage area of 756 square miles, is located on the Contoocook River about 1,800 feet below the Mast Yard Hill highway bridge, 2.5 miles upstream of Penacook, New Hampshire. The dam at this location would consist of rolled-earth embankment on the two abutments and a concrete, gate-controlled section across the river, containing five 40-foot by 20-foot tainter gates and one 24-inch conduit through which a minimum flow of 90 cubic feet per second would be released at all times down the Contoocook River. At a normal power pool elevation of 357 feet, mean sea leve, the reservoir would extent about 12 miles up the river. Only sufficient storage for daily pondage requirements would be provided. A canal, approximately 15,000 feet long, would divert flows from the reservoir to a pentock intake, thence through a penstock to a powerhouse on the west bank of the Merrimack River about 3,500 feet upstream of the existing Sewall's Fall Dam. The project would utilize a gross head of 114 feet between a headwater elevation of 357 feet, and a tailwater elevation of 243 feet. One 30,000 kilowatt generator, producing an average annual output of 63,700,000 kilowatt-hours at a capacity factor of 24 percent would be installed in the powerhouse. The project would necessitate the acquisition of approximately 1,700 acres of land and the raising or relocation of several bridges and short sections of secondary roads.

The total estimated first cost of the project is $39,501,000.

MOORES FALLS

This site, with a drainage area of 3,200 square miles, is located on the Merrimack River about eight miles below Manchester and nine miles above Nashua, New Hampshire. The dam at this location would consist of a concrete section containing ten 40-foot by 20-foot tainter gates and one skimmer gate, with a powerhouse on the left bank. Earth embankments at both abutments would complete the closure. The reservoir, at normal full power pool would extend upstream 8.5 miles to the tailwater of the existing Amoskeag Power development. It would provide sufficient storage for daily pondage requirements. The project would develop a gross head of 35 feet between the headwater elevation of 130 feet mean sea level, and the tailwater elevation of 95 feet. One 50,000 kilowatt generator producing an average annual output of 101,000,000 kilowatt-hours at a capacity factor of 20 percent, would be installed in the powerhouse. Construction of the project would require the acquisition of approximately 1,400 acres of land and the relocating or raising of short sections of highways and the Boston and Maine Railroad. The total estimated first cost of the project is $56,239,000.

MEADOWS

This site, with a drainage area of 560 square miles, is located on the Deerfield River about 3.4 miles east-northeast of Conway, Massachusetts, and one-quarter mile upstream from the Stillwater highway bridge. Rock outcrops appear on both banks. Information is available on the results of foundation explorations at the site. The development would consist of the construction of an earth-fill dam with a 200-foot concrete, gate-controlled spillway and a 32-foot concrete non-overflow section. The structure would have an overall length of about 730 feet and a maximum height of about 85 feet. A gross head of 61 feet would be available between headwater and tailwater elevations of 211 and 150 feet, m.s.l., respectively. A powerhouse situated on the left bank immediately downstream from the toe of the dam, would contain generating facilities for 30,000 kilowatt in one unit which would produce an average annual output of 41,800,000 kilowatt-hours at a capacity factor of 16 percent. Construction would necessitate the acquisition of about 170 acres of land of which about 120 acres would have to be cleared. The total estimated first cost of the project is $29,310,000.

ENFIELD

The Enfield site, with a drainage area of 9,719 square miles, is located on the Connecticut River about 1,250 feet above the highway bridge at Windsor Locks, Connecticut. Foundation explorations have been made at the site and bedrock conditions were found suitable for the construction of a concrete dam. The dam, including an earth dike on the east bank, would have a length of about 3,000 feet and a height of 55 feet above the stream bed. A gross head of 31 feet would be developed between headwater and tailwater elevations of 45 feet and 14 feet, Hartford datum (44.45 and 13.45 feet, m.s.l.), respectively. With three feet of drawdown, pondage of 9,100 acre-feet would be available. A powerhouse situated in the downstream face of the dam would contain generating facilities for 60,000 kilowatts, in three units. The average annual output of the plant, under improved conditions of flow afforded by the inventory storage projects, would be 261,900,000 kilowatt-hours at an annual capacity factor of 50 percent. The area of the pond at an elevation of 45 feet (44.45 feet, m.s.l.) would be 3,280 acres. The pond would extend upstream to Holyoke, Massachusetts, causing loss of head at one plant on the Chicopee River and at six installations on the second and third level canals at Holyoke. The principal installation at Holyoke would not be affected. High river discharge in excess of plant capacity would be controlled through operation of 17 sectional wheeled gates 40 feet long by 35 feet high. Existing navigation requirements in the river would be accommodated through provision of a small lock at the dam. This lock, with a lift of about seven feet, would raise craft from an elevation of 38 feet, Hartford Datum, the present elevation in the existing canal, to the proposed headwater elevation of 45 feet (44.45 feet, m. s. l.). The existing downstream lock would be retained. The railroad bridge about 2,000 feet upstream from the dam would have a limiting vertical clearance of about 13 feet upon completion of the project. Space would be provided in the dam for construction of a commercial lock at a later date should navigation conditions warrant. A fishway and fish elevator would be provided. The project would require the acquisition of about 1,600 acres of land of which 140 acres would require clearing. Construction would require the purchase of many properties at Warehouse Point, including buildings. The Enfield Sewage Treatment Plant would be relocated, an an existing dam about four miles upstream would be removed. The railroad embankment at Windsor Locks would be suitably protected, necessary street relocations accomplished, and miscellaneous waterfront repairs made. The total estimated first cost of the project is $94,367,000 exclusive of the cost of acquiring existing water rights.

DICKEY-LINCOLN SCHOOL LAKES, MAINE

FACT SHEET

I. GENESIS.

Dickey-Lincoln School Lakes evolved as a result of a study of the Development of Tidal Power at Passamaquoddy, a system of tidal bays studied since 1919 by both private and public engineers. The most comprehensive report was that completed by the International Joint Commission in April 1961 after 3 years of study and a cost of $3 million. The Commission concluded that the project was not economically feasible under the then existing conditions. At the request of President John F. Kennedy, the Commission report was reviewed to determine if the project was feasible in view of the advanced engineering techniques and prevailing economic conditions. In July 1963, a report was submitted to the President, which concluded that application of a different use-concept of power coupled with advanced engineering techniques would result in a favorable report.

On July 16, 1963, the President directed the Departments of Interior and Army to make additional studies to supplement the July 1963 report. An Army-Interior Advisory Board on Passamaquoddy and Upper Saint John River was formed. Interior performed power studies, power transmission, marketing benefits and other economic aspects. The Corps of Engineers developed the physical components of the project.

The Study Committee completed its evaluation in August 1964, and submitted its report to the Secretary of the Interior. Recommendations included: early authorization of the Passamaquoddy Tidal Project and Upper Saint John River Developments and early construction of the project to develop low cost firm power for Maine and peaking power for the remainder of New England.

The Secretary of the Interior submitted a report on 9 July 1965 to President Johnson summarizing the August 1964 report. Subsequent to August 1964, a review updated the power benefits. The power rates were reduced due to larger, more economical developments by the power industry since the previous analyses. The reduction caused the benefit-to-cost ratio for the Passamaquoddy Power Project to fall below unity (.86 to 1). The benefit-to-cost ratio for Dickey-Lincoln School Lakes was a sound 1.81 to 1.

October 1975

One recommendation included in the July 1965 report approved by President Johnson was:

> "Immediate authorization, funding, and construction of the Dickey and Lincoln School projects on the Saint John River and their associated transmission system. Construction would be contingent upon completion of necessary arrangements with the Canadian government. This would also have the immediate and major by-product of preserving the famed Allagash River in Maine, one of the few remaining wild rivers east of the Mississippi River."

The Dickey-Lincoln School Lakes Project was authorized by the 1965 Flood Control Act, Public Law 89-298 dated 27 October 1965, substantially in accordance with the plans included in the August 1964 report.

II. PROJECT DESCRIPTION.

A. Physical Characteristics

Dickey Dam is located on the Upper Saint John River immediately above its confluence with the Allagash River near the Town of Dickey and 28 miles above Ft. Kent in Aroostook County, Maine. As authorized the dam would be an earthfill structure impounding a reservoir with gross storage capacity of 7.7 million acre-feet for power, flood control and recreation. The reservoir area would total 86,000 acres at maximum pool elevation of 910 feet mean sea level (msl). Three dikes would be located in saddle areas along the reservoir perimeter to prevent overflow into adjacent watersheds.

Dickey Dam would have a total length of 10,600 feet and a maximum height of 335 feet above streambed. Its outlet works consist of a 26-foot diameter concrete lined tunnel, 2,130 feet long. The power facilities include eight generating units at 95,000 Kilowatts (KW) for a total installed capacity of 760,000 KW. The project would be operated for peaking power purposes.

Lincoln School Dam is located on the Upper Saint John River, 11 miles downstream from Dickey Dam. It provides for an earthfill dam impounding a reservoir with useful storage capacity of 24,000 acre-feet for purposes of regulating discharges from Dickey Dam and for power generation. Its reservoir would encompass 2,150 acres at its maximum pool elevation of 610 feet msl.

Lincoln School Dam would be 1600 feet long and have a maximum height of 85 feet. Its power facilities consist of two units at 35,000 KW each for a total installed capacity of 70,000 KW. The project would be operated as a base load power plant.

The construction cost for the dams and appurtenances totals $463.0 million based on 1 October 1975 price levels.

B. Operational Characteristics

The project would be operated principally as a peaking power plant. In this role the project would not be a high energy producing (i.e. Killowatt-hours) facility. A peaking power project is designed to operate for short periods of time to meet critical daily peak demands. It has quick starting capability and provides spinning reserve for load protection. Typical peaking plants are hydroelectric projects - both conventional and pumped storage - and gas turbine units. On the other hand, base load power is provided by large efficient fossil-fueled or nuclear steam plants which operate virtually continuously and as a result are high energy producing installations. However, these latter plants are not suitable for peaking use and load protection because of economic and operating considerations. The 1970 National Power Survey published by the Federal Power Commission notes that the current trend towards construction of very large fossil-fueled and nuclear steam-electric base load units has increased the need for plants designed specifically for meeting daily peak demands.

In addition to its reliability, a hydroelectric facility has a lower operating cost than alternative power sources because it does not rely upon costly fuels. Water is a continuous and clean source of power. Beyond the economic aspects, there would also be an annual savings in natural resources. To produce an equivalent amount of electrical energy, fuel consumption - dependent upon the type of alternate - would total 1.7 million barrels of oil or 600,000 tons of coal, or 9.2 billion cubic feet of gas.

C. Generating Time

The operation of Dickey Dam's power facilities is very flexible and can vary on any given day to meet a specific peak demand. The project is capable of generating to full capacity about 2½ hours per day for seven days a week or 3½ hours daily for five days a week. During periods of peak demand the generating time could be increased to seven hours per day, seven days per week if desired.

The Lincoln School reregulating dam can normally operate 10 hours per day seven days a week. When the Dickey project operates 7 hours per day, the Lincoln project is capable of generating energy 24 hours per day.

In the event of an electrical blackout, the project is capable of generating electricity for a continuous period of up to 35 days. Under normal operating conditions, the project will generate energy 12 months per year.

D. Construction Period

Construction of the project, including all necessary land acquisition, will require approximately 7½ years. Initial power-on-line would be scheduled 6½ years after initiation of construction and total power-on-line would be realized one year later.

III. PROJECT ECONOMICS.

A. General

The project's average annual benefits are currently estimated as follows: (1 October 1975 Price Levels)

Benefit	Amount
Power	$56,549,000
Flood Control	83,000
Area Redevelopment	1,067,000
Recreation	1,250,000
Total Benefits	$58,949,000

The average annual cost of the project reflecting amortization of the initial investment and annual operation and maintenance cost totals $22,850,000. This results in a benefit-to-cost ratio of 2.6 to 1.

1. Power

As noted, power would be the principal benefit realized through construction of the Dickey-Lincoln School Lakes Project. On-site annual power generation of 1.2 billion kilowatt hours would result from the total installed capacity of 830,000 KW. Additional power generation of 350 million kilowatt hours would also be gained by downstream Canadian power plants due to regulated flows from Lincoln School Lake of which 50% would be allocated to the United States.

The peaking power capability of the project would provide an estimated 14% of the New England peaking power capacity required in the mid-1980's.

2. Flood Control

The flood control benefit results from elimination of flood damages below the project site. Fort Kent, located about 28 miles below Dickey Dam, has experienced ten floods during the past 48 years of record. The most recent floods occurred in May 1961, May 1969, April 1973 and May 1974. The May 1974 flood stages exceeded the record flood of April 1973 and caused damages estimated at $3.0 million. These losses would be prevented by the project. In view of the uncertain status of Dickey-Lincoln School Lakes and the recurring flood problem at Ft. Kent, a small local protection project has been formulated under Section 205 of the 1948 Flood Control Act, as amended, that will provide some degree of protection to the Town of Ft. Kent. The proposed dike and pumping station will protect to a 100 year frequency flood level and be limited principally to the commercial center of Ft. Kent. The project has been approved by the Governor of Maine and is currently under design. Construction is dependent upon the availability of future appropriations.

Dickey-Lincoln School Lakes would provide full protection to the entire Ft. Kent area and other downstream areas.

3. Redevelopment

The Area Redevelopment benefit represents the effect of added employment resulting from the project. The Dickey-Lincoln School Project is located in the part of Aroostook County which is classified as a Title IV (1) Economic Development Area denoting an area of substantial and persistent unemployment. Numerous employment opportunities would arise and the associated wages related to project construction and future operation and maintenance would result in substantial relief to the economically depressed area.

4. Recreation

The recreation benefit is a preliminary estimate of general recreation, hunting and fishing use developed at the close of earlier preconstruction planning activity. As presently envisioned limited facilities such as campsites, comfort stations and boat launching ramps would be provided. A preliminary recreational master plan will be developed - in conjunction with appropriate State and Federal agencies - in the early stages of current planning effort.

B. Economic Analyses

The justification for authorization of all Corps of Engineers' projects is measured in terms of the benefit-to-cost ratio. The economic analysis used to develop this yardstick is based on standards prescribed by Senate Document No. 97, 87th Congress, entitled Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources. Total project benefits for Dickey-Lincoln School Lakes are comprised of at-market power, total downstream energy, flood control, recreation and area redevelopment type benefits. The power benefits for Dickey-Lincoln School Lakes are equated to the cost of privately-financed equivalent alternative sources of power. The unit power values, furnished by the Federal Power Commission, are based on gas turbines for that portion of project power expected to be marketed in the Boston area for peaking purposes and a combined cycle generation plant as an alternative for that portion to be marketed in Maine.

The project cost is evaluated on an annual basis reflecting amortization of the investment and annual operation and maintenance expenses. The cost has been increased to provide for the transmission of power by adding 50 percent of the annual cost of a line between the project and Boston. It has been assumed that the remaining one-half of the annual cost will be derived from the wheeling by others of off-peak power. The interest rate used in the economic evaluation is 3¼% and the period of analysis is 100 years. Attached as Table I is a summary of the economic analysis.

The 3¼ percent interest rate used in the economic analysis has been the subject of considerable discussion. Accordingly, an explanation of the derivation of this rate is appropriate. The interest rate is in accordance with a Water Resources Council (WRC) regulation implemented in December 1968. This regulation revised the method of computing the interest rate as previously outlined in SD 97. The regulation permitted an exception, however, for those projects already authorized such as Dickey-Lincoln School Lakes which was authorized in 1965. The exception noted that if an appropriate non-Federal agency provided - prior to 31 December 1969 - satisfactory assurances that requirements of local cooperation associated with the project would be met, then the previous interest rate would be retained. At Dickey-Lincoln School Lakes, local cooperation would be required for the cost sharing of recreational facilities. Assurances were received from the Governor of Maine by letter, dated 24 February 1969, that the non-Federal requirements would be fulfilled at the appropriate time. As a result, the interest rate was retained at 3¼%.

The WRC subsequently established new principles and standards for water resource planning effective in October 1973. A section of these new standards included the provision for increasing the interest rate to 6-7/8%. However, the Water Resources Development Act of 1974, enacted by the Congress on 7 March 1974, included a section which requires that interest rates used for water resource projects be consistent with the implementation of the December 1968 WRC regulation. Accordingly, the 3¼% interest rate remains firm for Dickey-Lincoln School Lakes. The prevailing rate for new water resource projects is 6-1/8%. As a point of interest if Dickey-Lincoln School Lakes were evaluated on this higher rate the benefit-cost ratio would be 1.5 to 1.

The Corps of Engineers also uses a procedure referred to as an "Economic efficiency test." The objective of an ideal system operation is to meet area power demands at least cost to consumers. Therefore the least costly addition to a region's capacity could be considered as a yardstick for purposes of making a decision regarding such additions. The "economic efficiency test" provides for such a determination. Basically the test provides for a comparison of the costs of providing an equivalent amount of power from the most feasible alternative, likely to develop in the absence of the project, evaluated on a basis comparable with the determination of the Federal project costs (with respect to interest rate i.e. 3¼%, taxes and insurance). The Corps "economic efficiency test" indicates that the annual at-market charge for Dickey-Lincoln School Lakes power amounts to $22,850,000 while alternative equivalent power charges amount to $45,758,000. This results in a ratio of 2.0 to 1 in favor of Dickey-Lincoln School Lakes. This means that even if private utilities could obtain financing equivalent to the Federal rate, water resource benefits could be provided by Dickey-Lincoln School at half the cost of the most feasible alternatives likely to develop in its absence. The attached Table II illustrates the "economic efficiency test".

C. Repayment Analysis

The above analyses are used to define the economic worth of the project. The financial value of power, however, is determined through the repayment analysis. Marketing of electric power from Federal projects is the basic responsibility of the Secretary of Interior as authorized by Section 5 of the 1944 Flood Control Act. Repayment rates must be sufficient to recover costs of power production and transmission including annual operation and maintenance expenses. The total investment allocated to power must be repaid over a reasonable period of years. As a matter of administration policy, this period has been specified as 50 years. On 29 January 1970, the Secretary of Interior, under his administrative discretion to establish power rates, instituted new criteria for determining interest rates for repayment purposes for projects not yet under construction. The current interest rate used for Dickey-Lincoln School Lakes repayment under this revised criteria is 6-5/8%. The resulting analysis shows that power from Dickey-Lincoln School Lakes could be marketed at 35.23 mills/Kwh as compared to 43.91 mills/Kwh for the private alternatives. On an annual basis this represents a savings of about $10.8 million.

The difference between the economic analyses previously described and the repayment analysis warrants further clarification. This has caused a considerable amount of misunderstanding and misinterpretation. The economic analyses - both for the benefit-to-cost ratio determination and the "economic efficiency test" are economic parameters measuring a project's worth. These analyses are not unique to Dickey-Lincoln School Lakes. The benefit-to-cost ratio is employed universally by the Corps in measuring a project's economic justification. The "economic efficiency test" is also universally used by the Corps in conjunction with projects having generation of electric power as a project purpose. The economic analyses utilize a 3¼% interest rate and 100-year period of evaluation. On the other hand, the repayment analysis - which will ultimately be computed by the Department of Interior - is a financial measure which determines the appropriate price at which bulk power must be marketed to return the total annual investment allocated to power. For this analysis, an interest rate of 6-5/8% and a 50-year repayment period are used.

IV. ENVIRONMENTAL STUDIES.

A. General

Detailed data essential to a comprehensive environmental evaluation consistent with the National Environmental Policy Act of 1969 (NEPA) were not developed for Dickey-Lincoln School Lakes during earlier preconstruction planning which was terminated in the fall of 1967, prior to passage of NEPA. With the resumption of activity in 1974, environmental studies and preparation of an Environmental Impact is receiving priority attention. A final Environmental Impact Statement must be on file with the Council on Environmental Quality prior to initiating any land acquisition or construction.

An initial activity in environmental studies was the preparation of a scope-of-work for the Environmental Impact Statement, completed in August 1975. The scope-of-work is the plan of action for developing a comprehensive Environmental Impact Statement. It identifies all significant environmental, social and economic impacts induced by the project and recommends methodology for measuring and evaluating these impacts. Contracts are underway with private consulting firms to develop data and analyze the various impacts.

B. Project Effect on the Allagash River

Construction of the Dickey-Lincoln School project will have no adverse effect on the Allagash River. The Dickey Dam site is located on the Upper Saint John River immediately above its confluence with the Allagash River. Consequently, the impoundment would have no effect on its outstanding free flowing characteristics.

C. Effect of Reservoir Drawdown

Dickey Lake is distinguished as a multi-purpose seasonal storage reservoir and is designed to regulate river flows for at-site and downstream power generation, flood control and water quality. Inherent with these functions is a pattern of seasonal change in storage content and accompanying pool stage fluctuation.

The New England Division of the Corps of Engineers has conducted computer simulation studies which, among other things, identify the extent of these reservoir fluctuations. The characteristics of the project were analyzed by continuous simulation of operation using 41 years of hydrologic record. These studies indicate that during the summer season from June to October the lake level would normally fall or rise only slightly, depending upon hydrologic and electric load conditions.

During a normal year the pool would be nearly full in June, following the spring refill period, and then fall about 1.5 feet by the first of October. Pool fluctuations due to daily power operations would be minute, generally less than 2 to 3 inches. The normal pool fluctuation during the summer season would be about 2 feet. The maximum drawdown experienced during the summer months for the 41 years of simulation was 4.5 feet.

Much has been written about the so-called "bath tub ring" effect due to drawdown. The exposed bottom for the normal summer drawdown of 2 feet would be about 1500 acres, equivalent to a 35 foot wide strip around the 350 mile periphery of the lake. Maximum drawdown, normally about 20 feet, would occur each year during the winter months when snow would effectively cover the exposed areas. The minimum power pool level of 868 feet msl occurred once during the 41 year simulation and was in the month of March just prior to the spring refill season. The difference in lake area between the full pool level at 910 feet msl and the minimum pool is 32,000 acres.

V. MARKETING OF POWER

The concept developed during the earlier studies envisioned the marketing of 725,000 KW of Dickey-Lincoln School Lakes output as peaking power to the Boston, Mass. area and the remaining 105,000 KW principally as base load power in the Maine market. This marketing concept is being reviewed by the Department of Interior.

The Department of Interior will be responsible for marketing the electric power from Dickey-Lincoln School Lakes per authority of Section 5 of the 1944 Flood Control Act. This statute requires that power be sold in such a manner as to encourage the most widespread use thereof at the lowest possible rates consistent with sound business practices. Section 5 further directs that preference in the sale of power and energy is to be given to public and cooperative power interests.

It will not be known how much power will be available to private utilities until Interior finalizes its marketing plans. Marketing studies currently being conducted indicate that power will probably be available to private utilities. Historically, the Department of Interior has not proceeded with definitive marketing and transmission plans until construction of the project is underway and the power-on-line date is capable of being met with some degree of certainty. Prior to that time, their studies are of sufficient depth to determine marketability and evaluate the financial feasibility of the power installation.

The existence of the New England Power Pool (NEPOOL) - comprised of the major utilities within New England - provides an effective vehicle through which Dickey-Lincoln School Lakes output could be utilized to the mutual benefit of New England. A report dated November 21, 1974 submitted to the New England Planning Committee of NEPOOL stated that, "the Dickey project capacity would be fully effective capacity to the interconnected New England system if it were dispatched in a peaking assignment during the 1985-1986 power year. The enormous storage reservoir makes it possible to use Dickey with maximum flexibility. It can run at full capacity whenever it is needed and can sustain that power level for the duration of any peak that the system experiences. It makes an ideal source of reserve with quick response, a fact that is most valuable to have as an option open to those responsible for load dispatching."

VI. CURRENT STATUS

Planning and design, previously terminated in late 1967 due to lack of funds, was resumed in the Fall of 1974 with the allocation of $949,000 in Fiscal Year 1975 (July 1974 through June 1975) funds. The only work accomplished in the interim was the annual updating of project costs and benefits. Construction costs were escalated using selective cost indices for specific work items. The power benefits have been updated annually by the Federal Power Commission.

Efforts and Activities currently under way:

Environmental -

- Prepared a "Scope-of-Work" for accomplishment of an Environmental Impact Statement.
- Aquatic Ecosystem & Fisheries Analysis.
- Terrestrial Ecosystem (Vegetation & Wildlife Analysis).
- Social - Economic Impacts Analysis.
- Archeological Studies.
- Power Alternatives Study.
- Water Quality Studies.
- Seismic Studies.
- Geological Studies.
- Preparation of an Environmental Impact Statement.

Project Planning & Engineering -

- Hydrology and Hydraulic Studies.
- Hydropower Studies including feasibility of modifying authorized units to provide pumped storage capability.
- Recreational Concept and preliminary planning.
- Real Estate planning and gross appraisals.
- Surveying and Mapping of Construction Sites.
- Construction Materials surveys.
- Highway Relocation Studies.
- General Layout and Design Activities.
- Updating of Project Cost Estimates & Development of Project Economics Data.

Coordination has been and will continue to be established with appropriate Federal, State and local agencies; Canadian interests and private interests as project planning and engineering progresses.

Since renewal of project planning in late 1974 it has become apparent that much environmental baseline data is lacking for this remote area of northern Maine. Also in view of the seven year hiatus in planning and design, project features must be reviewed and redesigned as required to reflect criteria changes and current conditions. Therefore, the prime current objectives are to: collect environmental baseline data; prepare an Environmental Impact Statement; revise project features and general design to reflect current requirements and conditions; and, prepare updated project cost estimate and economic analysis to reflect changes.

TABLE I

DICKEY-LINCOLN SCHOOL LAKES

ECONOMIC ANALYSIS - ANNUAL COSTS AND BENEFITS (October 1975 P.L.)
(Based on 3-1/4% interest rate and 100-year project life)

TOTAL INVESTMENT - DAMS	
Construction Cost of Dams	$463,000,000
Interest During Construction	37,900,000
Total Investment	$500,900,000
Capital Recovery factor 100 yr. life	.03388
ANNUAL COSTS - DAMS	
Interest and Amortization	$ 16,970,000
Operation and Maintenance	1,850,000
Major Replacements	323,000
Loss of Land Taxes	128,000
Sub-Total Dams	$ 19,271,000
TOTAL INVESTMENT - TRANSMISSION LINES	
Construction Costs of Transmission Line	$162,120,000
Interest During Construction	7,900,000
Total Investment	$170,020,000
ANNUAL COSTS - TRANSMISSION LINES	
Interest and Amortization	$ 5,760,000
Operation and Maintenance	884,000
Major Replacements	514,000
Sub-Total Trans. Lines	$ 7,158,000
TOTAL ANNUAL COSTS	
Dickey-Lincoln School Lakes	$ 19,271,000
Transmission (50%)	3,579,000
ANNUAL COSTS	$ 22,850,000
ANNUAL BENEFITS (See next page)	$ 58,949,000
B/C RATIO	2.58 to 1

TABLE I (Cont'd)

DICKEY-LINCOLN SCHOOL LAKES

ECONOMIC ANALYSIS - ANNUAL COSTS AND BENEFITS (October 1975 P.L.)

ANNUAL BENEFITS	
Marketed in Maine	
105,000 kw x .95 x $45.00	$ 4,489,000
372,000,000 kwh x .95 x $.0215	7,598,000
Marketed in Boston	
725,000 kw x .905 x $27.00	17,715,000
782,000,000 kwh x .929 x $.032	23,247,000
Downstream	
350,000,000 kwh x $.010	3,500,000
Sub-Total Power	$56,549,000
PREVENTION OF FLOOD DAMAGES	83,000
RECREATION	1,250,000
REDEVELOPMENT	1,067,000
TOTAL ANNUAL BENEFITS	$58,949,000

Kw = Kilowatts
Kwh = Kilowatt hours

TABLE II

DICKEY-LINCOLN SCHOOL LAKES

ECONOMIC EFFICIENCY TEST

(Comparably financed i.e. 3-1/4%)

ALTERNATIVE COSTS

Power marketed in Maine		
105,000 kw x .95 x $18.00		$ 1,796,000
372,000,000 kwh x .95 x $.0215		7,598,000
Power marketed in Boston		
725,000 kw x .905 x $11.00		7,217,000
782,000,000 kwh x .929 x $.032		23,247,000
Downstream		
350,000,000 kwh x $.010		3,500,000
	Sub-Total	$43,358,000
*Adjustment for flood control		83,000
*Adjustment for recreation		1,250,000
*Adjustment for redevelopment		1,067,000
	Total Alternative Cost	$45,758,000
	Annual Cost, Dickey-Lincoln School	22,850,000
	Comparability Ratio	2.0 to 1

*Flood control, recreation and redevelopment benefits which are provided incidentally to construction of Dickey-Lincoln School would be foregone by the alternative. Therefore, the values of these benefits are added to the alternative in order to obtain a valid comparison.